TRANSACTIONS and PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

VOLUME XXXVII
Part III
SESSION 1956-57

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PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CXXI

OCTOBER 18, 1956.

Dr. J. A. Macdonald, President, in the Chair.

Mr. L. Cobley, Mr. T. B. Tomlinson and Dr. D. F. O. Russell were elected Ordinary Fellows and Mrs. M. Mackie was elected an Ordinary Member.

Dr. J. A. Macdonald delivered his Presidential Address, entitled "The Fungal Cell".

NOVEMBER 15, 1956.

Mr. J. Grant Roger, Vice-President, in the Chair.

Mr. Stuart Burns, Mr. A. Pratt and Mr. M. Hossain were elected Ordinary Fellows.

Dr. Magnus Pyke delivered an address entitled "Chemicals for Adam's Garden".

NOVEMBER 22, 1956.

Professor J. R. Matthews in the Chair.

A Meeting of the Society was held in Aberdeen. Mr. M. R. Henderson gave a lecture entitled "The Flora of Malaya", and Fellows and Members visited the Cruikshank Botanic Garden.

DECEMBER 13, 1956.

Dr. J. A. Macdonald, President, in the Chair.

Mr. P. J. B. Woods and Dr. J. H. Lennard were elected Ordinary Fellows.

Dr. Dorothy Downie delivered an address entitled "Fungi Associated with Scottish Orchids".

JANUARY 17, 1957.

Dr. J. A. MACDONALD, President, in the Chair.

The President referred to the death of Sir WILLIAM WRIGHT SMITH, who had been a Fellow of the Society for Fifty-four years, and had three times acted as President of the Society. The Fellows and Members present stood in silence for one minute, in memory of Sir William.

Mr. J. R. JACK was elected an Ordinary Member.

The following papers were read to the Society:

"Recent Experimental Work on Bracken Control," by Dr. ELSIE CONWAY.

"Indirect Effects of Myxomatosis on the Scottish Vegetation," by Mr. J. GRANT ROGER.

The following papers were read by title:

"Further Observations on the Bryophyte Flora of the Isle of May," by E. V. WATSON.

"Snow Mould on Upland Pastures in North Scotland," by ELIZABETH G. GRAY and I. A. NICHOLSON.

A Dinner was held in the Saint Andrew Hotel, and was attended by some fifty Fellows and their guests. Professor J. R. MATTHEWS, C.B.E., was the principal speaker.

FEBRUARY 14, 1957.

Dr. J. A. MACDONALD, President, in the Chair.

Dr. G. B. WALLACE and Dr. A. M. M. BERRIE were elected Ordinary Fellows.

Professor D. H. VALANTINE read a paper entitled "Problems of Evolution in *Viola*"

MARCH 14, 1957.

Dr. J. A. MACDONALD, President, in the Chair.

Mr. JOHN TURNBULL was elected an Ordinary Fellow.

A group of short papers on "Recent Work on the British Flora" was read. Miss E. BEATTIE gave a "Progress Report on the Mapping Scheme in Scotland", Mr. A. CRUNDWELL discussed "Recent Additions to the Moss Flora of Scotland" and Mr. J. ANTHONY gave an account of "The Flora of Bettyhill, Sutherland".

APRIL 11, 1957.

Dr. J. A. Macdonald, President, in the Chair.

Miss Joan S. Cuthbert, Dr. D. A. Ratcliffe, Miss Lesley M. Sleigh, Dr. G. W. T. H. Fleming, Mr. I. A. Nicholson, Mr. A. C. Crundwell and Mr. J. R. Mackay were elected Ordinary Fellows.

Dr. H. R. Fletcher gave an address entitled "The Royal Horticultural Society's Garden, Wisley".

Members of the Scottish Rock Garden Club were guests of the Society at this Meeting.

MAY 2, 1957.

Dr. J. A. Macdonald, President, in the Chair.

Dr. P. C. de Kock read a paper entitled "Chelation Studies in the Iron Nutrition of Plants with Special Reference to Peat". Dr. John Smith read a paper entitled "Establishment and Use of Grasses and Clovers on Deep Peat".

JUNE 13, 1957.

Dr. J. A. Macdonald, President, in the Chair.

The following British Honorary Fellows were elected:

Professor Irene Manton, Department of Botany, Leeds University.

Sir Eric Ashby, Queen's University, Belfast.

Dr. W. B. Turrill, Royal Botanic Gardens, Kew.

The following Foreign Honorary Fellows were elected:

Professor Pierre Chouard, La Sorbonne, Paris, France.

Dr. F. Kirchheimer, Elsasserstrasse 2, Freiburg im Br., Germany.

Professor H. J. Lam, Rijksherbarium, Nonnensteeg, Leiden, Netherlands.

Professor G. H. Lawrence, Bailey Hortorium, Ithaca, New York, U.S.A.

Professor B. K. Schischkin, Botanical Institute of the Academy of Science of the U.S.S.R., Popov Street, Leningrad, U.S.S.R.

Professor E. C. Stakmann, Department of Botany, University of Minnesota, St. Paul, U.S.A.

The following Office-Bearers were elected for Session 1957-58:

PRESIDENT

H. R. Fletcher, Ph.D., D.Sc., F.R.S.E., V.M.H.

VICE-PRESIDENTS

D. H. N. Spence, B.Sc., Ph.D.
J. A. Macdonald, Ph.D., D.Sc., F.R.S.E.
R. M. Adam, F.L.S.
C. E. Foister, B.A., Ph.D., Dip. Agr. Sci., F.R.S.E.

COUNCILLORS

J. Smith, D.Sc.
Miss M. M. Macdonald, B.Sc.
Miss P. J. Watson, Ph.D.
Alexander Nelson, D.Sc., F.R.S.E.
Miss L. I. Milne.
H. H. Davidian, B.Sc.
W. A. Clark, B.Sc., Ph.D.
C. H. Gimingham, B.Sc., Ph.D.
J. G. Roger, B.Sc., F.L.S.
L. S. Cobley, B.Sc., A.I.C.T.A.

Honorary Secretary—P. S. Green, B.Sc., F.L.S.

Assistant Secretary—Miss D. E. Purves.

Cryptogamic Secretary—D. M. Henderson, B.Sc.

Editor—Miss A. M. MacLeod, B.Sc., Ph.D. (Heriot-Watt College, Edinburgh).

Treasurer—R. T. Hunter, C.A.

Auditor—C. A. Scott, C.A.

The TREASURER, Mr. R. T. HUNTER, submitted the following Statement of Accounts for the Session 1956-1957:

INCOME.

		£	s.	d.
Annual Subscriptions		£123	10	0
Arrears of Subscriptions recovered		22	0	0
Transactions sold		70	14	8
Interest on Investments		26	10	4
Subscriptions to Publications Fund		1	0	0
Income from Botanical Society Trust Fund		12	13	0
Income Tax recovered, 1956-57		15	16	4
Grants—				
Carnegie Trust	£100 0 0	100	0	0
Transferred from Capital Fund		—		
		£372	4	4

EXPENDITURE.

	£	s.	d.
Printing *Transactions*, Vol. 37 (Part II) *Estimate*	£160	0	0
Printing Billets, etc.	81	3	11
	£241	3	11
Stationery, Postages, etc.	16	9	3
Fire Insurance on Books	0	5	0
Projector and Film	3	3	0
Bank Charges	1	4	2
Lecture Expenses	3	18	0
Honorarium to Treasurer	5	5	0
Honorarium to Assistant Secretary	5	5	0
Excess of Income over Expenditure	95	11	0
	£372	4	4

BALANCE SHEET AS AT 30TH APRIL 1957.

LIABILITIES.

I. Capital Funds—		
Balance brought forward from 1955-56		£913 1 7
Add—Life Compositions received in 1956-57	£30 0 0	
Donations	9 4 6	
		39 4 6
Transferred to Revenue		£952 6 1
Add—Excess of Income over Expenditure, 1956-57		95 11 0
		£1047 17 1
II. Subscriptions received in advance—		
1957-58. R. M. Gorrie	£1 0 0	
T. W. Summers	1 0 0	
Mrs. Elmy	0 5 0	
E. W. Debney	1 0 0	
1958-59. E. W. Debney	1 0 0	
III. Accounts Outstanding—		
Printing *Transactions*, Carriage and Posts, etc.	£160 0 0	
Assistant Secretary	0 5 0	
		160 5 0
		£1212 7 1

ASSETS.

I. British Government Securities—		
(a) £200 3½% War Stock at cost		£194 18 3
(b) £258 2s. 6d. British Transport 3% Guaranteed Stock 1978-88 at cost		216 18 6
(c) £100 4% Defence Bonds (Conversion Issue) at cost		100 0 0
(d) £100 3½% Defence Bonds (Conversion Issue) at cost		100 0 0
(e) £250 3% Savings Bonds 1965-75 at cost		253 18 3
		£865 15 0
II. Bank Balances—		
(a) Sum at Current Account with Clydesdale & North of Scotland Bank, Ltd.	£16 15 5	
(b) Savings Account—Bank of Scotland	21 17 2	
(c) Edinburgh Savings Bank Account No. 129	207 19 6	
		246 12 1
III. Grant due from Carnegie Trust		100 0 0
IV. Income Tax Reclaim 1956-57 (received 30.4.57)		
		£1212 7 1

(Sgd. **RONALD T. HUNTER, C.A.**, Treasurer.

EDINBURGH, 14th May 1957.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for the Session 1956-57 and have found them correct. I have also checked the foregoing Abstract and found it correct. I have seen the securities for the Invested Funds and found them in order.

(Sgd.) CHARLES A. SCOTT, C.A., Auditor.

SIR WILLIAM WRIGHT SMITH LECTURESHIP FUND.

SESSION 1956-57.

Balance of Fund brought forward from 1955-56		£301 14 1
Interest on £250 3½% War Loan	£8 15 0	
Interest—Edinburgh Savings Bank	3 12 9	
		12 7 9
		£314 1 10
Expenses		*Nil*
		£314 1 10
Being—		
£250 3½% War Loan at cost	£203 12 0	
Edinburgh Savings Bank Account 312 ..	110 9 10	
		£314 1 10

(Sgd.) RONALD T. HUNTER, C.A., Treasurer.

EDINBURGH, 14th May 1957.—I hereby certify that I have audited the Accounts of the Sir William Wright Smith Lectureship Fund for the Session 1956-57, and have found them correct. I have seen the securities for the Invested Funds and found them in order.

(Sgd.) CHARLES A. SCOTT, C.A., Auditor.

The HONORARY SECRETARY, Mr. P. S. GREEN, submitted the following Report from Council:

The Membership of the Society, including the new Honorary Fellows, stands at present at 345, made up as follows: 12 Honorary British Fellows, 25 Honorary Foreign Fellows, 247 Ordinary Fellows (of whom 83 have compounded for life), 30 Ordinary Members, 30 Lady Members and 1 Associate. During the year 18 Ordinary Fellows and 2 Ordinary Members have been elected, 2 Ordinary Fellows have resigned and 5 Ordinary Fellows have died. The deaths of Sir John Stirling Maxwell and of Sir William Wright Smith are noted with especial regret.

Eight ordinary meetings were held during the Session, and additionally a very successful meeting was held in Aberdeen during November. The Annual Cryptogamic Foray took place in the Peebles district from 29th September to 1st October. A Society Dinner was held in the Saint Andrew Hotel on 17th January, with Professor J. R. Matthews as guest of honour.

In recognition of all that Professor Matthews has done both for the Botanical Society and for Scottish Botany in general, the Council has decided to publish a special extra number of the *Transactions* in 1959 to mark the occasion of Professor Matthews' seventieth birthday. Colleagues, former students and botanical friends are being asked to contribute papers, and an appeal is being made to all Fellows and Members for donations towards the cost of publication.

As the Field Meetings held last summer did not attract many participants, it has been decided not to hold any such meetings this summer; an excursion has, however, been arranged to visit the Botanic Garden and the Botany Department at St Andrews University during June.

In an attempt to co-ordinate the activities of this Society with those of the University Biological Society, a Committee member of the University Biological Society has been co-opted on to the Council of the Botanical Society. It is hoped that this liaison with the student Society may stimulate the attendance of student members.

Contributions to the funds of the Society have been received from Mrs. Henry and from Mrs. Watt; these contributions are most gratefully acknowledged.

Once again the Council wished to express the indebtedness of the Society for a grant of £100 from the Carnegie Trust for the Universities of Scotland. This grant is made to help with the cost of publishing the *Transactions*, and without this generous help from the Carnegie Trust the Society would experience very great difficulty in maintaining an annual publication.

TRANSACTIONS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CXXI

PRESIDENTIAL ADDRESS.

Some Aspects of our Knowledge of the Fungus Cell.

By J. A. Macdonald
(Dept. of Botany, University of St. Andrews, Fife).

(Read, 11th October 1956.)

Before finally selecting this title for my address, an attempt was made to review the trends of thought and research in fungal cytology during the thirty years which have elapsed since I embarked on my undergraduate career as a botanist, in this lecture theatre. From the mass of information accumulated I have chosen, possibly somewhat arbitrarily, a small number of inter-related topics which will, I hope, go some way towards illustrating the truth that in the fungus cell, which may be less than 10μ in diameter, there must exist all the mechanisms necessary for successfully sustaining the life processes of an organism.

The chemical nature of the cell wall has been made use of in connection with the classification of the fungi. Frey (1950) attached phylogenetic importance to the absence of chitin in the Oomycetes, considering that this made probable for the group a line of descent independent of other fungi. Thomas (1928) stated that in 12 species of *Fusarium* the wall consisted of an outer covering of a protein-pectin complex and, finally, a basic chitin skeleton. Nabel (1939) showed that chitin was present in Zygomycetes and Chitridiaceae, and was absent from all

Oomycetes except Blastocladiaceae, from Saccharomycetes and from Laboulbeniales. Ritchie (1947), working with the hyphal walls of *Allomyces arbuscula,* obtained positive tests for chitin only. Cutter (1951) cites a number of papers which show that the thallus walls in the Chytridiales contain chitin and may contain cellulose also, while parts of the sporangium in *Nowakowskiella* and *Rhizophydium* are composed of pectic substances. Garzuly-Janke (1940) found that 67 different filamentous fungi had chitinous walls with no mannan, whereas 72 yeasts and yeast-like fungi had no chitin but did possess mannan. Skalicky (1954) stated that the cell walls of the Oomycete *Plasmopara curta* (Berk.) Skal. consisted of fungal cellulose which gave a red-violet colour with chlor-zinc-iodide. Simon and Hendrick (1955) showed by infra-red spectrophotometry that the spectra of the cellulose of the cell wall in *Saccharomyces* and *Hansenula* agreed more closely with that of Type II cellulose than with that of Type I cellulose which is present in bacteria. However, Thomas (1942) claimed that in the walls of *Pythium* a basic skeleton of chitin is overlaid with cellulose impregnated with fatty acids, and Roelofsen (1953) confirmed the findings of Northcote and Horne (1952) in showing that the dried cell walls of baker's yeast contain a small quantity of chitin as well as a large percentage of mannan.

The reported presence of chitin in *Pythium* and in the yeasts, which were earlier accepted as having chitin-free walls, suggests that a very exact study of the chemical composition of the walls in all groups is desirable to clear up once and for all the existence or otherwise of fundamental differences in wall structure between different groups. In particular, exact examination of the apical growth regions of hyphae should yield valuable information on the methods by which the mature wall is laid down and the order of deposition of the different classes of material, where the wall is not uniform in structure. The position and extent of this growth region is easily demonstrated in basidiomycete fungi such as *Marasmius* (Macdonald 1949b) and *Auricularia* (Duncan 1954). From electron microscope, X-ray and chromatographic studies, Mühlethaler (1956) considers that in the myxomycete *Dictyostelium discoideum* the membranes produced at the time of construction of stalk, spore wall and sorophore sheath are composed of cellulose which is essentially the same as that of higher plants.

Wall structure is of practical as well as of theoretical interest. Brian (1949) suggested that griseofulvin acts as a fungicide only on fungi with chitinous walls (Basidiomycetes, Ascomycetes, Fungi Imperfecti and Mucorales) and not on Oomycetes (Saprolegniales and Peronosporales) and certain yeasts. More recently, Napier et al. (1956) suggested that this substance acted only on immature chitinous walls.

A special problem connected with walls is that of formation of septa. Buller's (1941) views on the presence of pores in the transverse septa in fungi and the use made of the pores to allow the movement of invading nuclei during the diploidising process are too well known to require further expansion here. It is my view, however, that this claim can not be satisfactorily substantiated unless a technique is devised whereby haploid nuclei "labelled" with a suitable radio-active isotope are introduced into a monokaryon mycelium and it is shown that a subsequent, progressive pairing-up of one "labelled" and one "unlabelled" nucleus takes place throughout the originally monokaryotic hyphae. At present it is not possible to trace the movement and division of a diploidising nucleus in the manner which Buller's words suggest. Brodie (1942) found a central pore in the transverse septa of the hyphae of *Erysiphe graminis.* Ritchie (1947), studying the development of the sporangium in *Allomyces arbuscula,* found the development of the new wall to be centripetal. The accretions were laid down in spots and 10 minutes were required for complete septum formation. Between crossed nicols with a Gypsum Red 1 filter, the orientation of the micelles of the septum was shown to be with their long axes tangential to the septum. Payak (1952), working with *Uromyces hobsoni* and *Puccinia thwaitesii,* described a wire-gauze-like septal region which allowed easy transfer of nuclei within the hyphae. Cammack (1952) has seen in *Uromyces scirpi* (= *lineolatus*) nuclei apparently trapped between two cells by the closing of a pore in a septum formed at the time of uredospore formation. Macdonald (1949b) has described similarly-placed dumbbell-like nuclei in living hyphae of *Marasmius androsaceus* at the first and other very early-formed septa close behind the growing hyphal tips. Of course, these pores may be regarded as permanent but of such small size that nuclei have to be squeezed into dumbbell-like shapes in order to pass through. This would seem to be an extraordinary state of affairs in a living organism, if it has to be accepted as a normal occurrence. Girbardt (1955, 1956a) does not believe that pores are present in mature transverse walls of *Polystictus versicolor, Trametes gibbosa* and *Pleurotus ostreatus.* Forsyth (1950) was unable to demonstrate pores in mature septa in *Mycena sanguinolenta.* These observations agree with some of my own on *Marasmius androsaceus, Polyporus betulinus* and *Coniophora puteana* (= *cerebella*). Bulging septa of apparently uniform thickness have been observed in these three fungi. It has been shown repeatedly e.g. by Macdonald (1949b), Forsyth (1950) and Girbardt (1955, 1956b), that nuclear division does not necessarily coincide exactly with septum formation. If nuclear division is slightly delayed beyond the beginning of septum formation, trapping of one of the resultant daughter nuclei at a pore could readily occur.

The diploidising of relatively old monokaryotic hyphae has always seemed to me to be a process of such limited usefulness that it is hardly likely to occur with any regularity in nature. However, the concept is widely held and the process has been fully described again recently by Dowding and Bakerspigel (1954).

Most work on fungus nuclei has been carried out at that stage of the life cycle closely associated with the formation of perfect spores. The great weight of the evidence supports the view that the meiotic process is similar in general terms to that occurring in higher plants. However, the fact that the entire nucleus in many fungi is only 2 to 3 microns in size—very much less than the size of a single chromosome in many other classes of organisms—has made an exact estimation of chromosome numbers and shapes, and even the interpretation of nuclear behaviour, a matter of very considerable difficulty. Modern fixation and staining techniques which maintain the life size of the nuclear components and show precisely the location of desoxyribose nucleic acid—which is often regarded as chromosome diagnostic—have allowed a re-check and extension of estimates of chromosome numbers throughout the fungi. Counts by P. Heim (1952, 1954) on 34 species of Ascomycetes and on species belonging to 100 genera of Basidiomycetes, together with counts by numerous other workers on some 130 genera, species and varieties have been noted. In general, there is agreement among different workers as to the chromosome number of the same species. Most numbers given are low, lying between 2 and 14, in marked contrast with the very high numbers recorded for myxomycetes such as *Hemitrichia vesparium* ($n = 90 \pm 3$ or 4) by Wilson and Ross (1955). The work of McGinnis (1953, 1954, 1956) on rusts is of special interest. In *Puccinia graminis* his photomicrographs show a chromosome number of $n = 6$ in the basidiospores. The existence of species such as *Puccinia coronata,* where he shows that $n = 3$, prompts him to comment that this is the basic chromosome number in the genus. This work raises the interesting, if rather theoretical, speculation as to what the effect would be of reducing experimentally the chromosome number in *Puccinia graminis* to that basic number. If increased ploidy leads to greater vigour, would the "virility" of the parasite be reduced by reversing the process? If one considers the number of substances already available which induce changes in chromosomes (some of which will be referred to later in this account) it is within the bounds of possibility that "permanent" genetic changes of the type under discussion, detrimental to the successful parasitism of a fungus, could be artificially induced on a commercial, nation-wide scale, thereby markedly reducing or even eliminating certain diseases.

The study of nuclei in vegetative cells has been carried out much less widely. That their behaviour at division does not always agree with that which is expected at a normal mitosis is indicated by reports of amitosis in species scattered throughout the fungi e.g. by Guilliermond (1927) in *Sporobolomyces,* and by Beams et al. (1940) in *Saccharomyces.* Yet Lindegren et al. (1956) believe that in yeast cells there is an intravacuolar spindle and that mitosis occurs on the spindle. The occurrence of amitosis is strongly suggested by observations of Kuhner (1927) on *Mycena galericulata* and on *Saccharomyces* by Mundkur (1954) using phase contrast microscopy. Phase contrast observations by Burns (1950) on *Uromyces* spp., by Girbardt (1956c) on *Polystictus versicolor* and *Trametes gibbosa* and by Duncan and Macdonald (unpublished) on *Auricularia auricula-judae* support the idea that irregularities occur.

Lindegren et al. (1956) bring forward evidence to support the view that in *Saccharomyces* a nucleolus appears in the nuclear vacuole of rapidly-growing, well-nourished cells. A nucleolus which is readily observable under phase contrast has been reported by Macdonald (1949a) and Girbardt (1955) in basidiomycete fungi. This is surrounded by a clear area of cytoplasm which Girbardt believes is bounded by a nuclear membrane. The size and shape of this nuclear region varies throughout the growth cycle. In a basidiomycete in which a nucleus a few microns in diameter is situated perhaps 100μ behind the growing cell tip, there must be some physical system for the transfer of information from the nucleus or genes to the seat of metabolic function. Gamow (1955) has sought the mathematical solution of this problem which he states as "the transfer of the hereditary informations from the chromosomes, where they are stored presumably in the form of long polynucleotide sequences, to the enzymes which, as all other proteins, are represented by long polypeptide chains. Mathematically the problem reduces to finding a procedure by which a long number written in fourdigital system (four bases forming the molecules of nucleic acid) can be translated in a unique way into a long word formed by 20 different letters (twenty amino acids which form protein molecules)". This is a more precise statement of the problem which I sought to express in very general terms and to which I offered a similar, albeit much simplified, explanation linked with work on the vegetative cells of *Marasmius androsaceus* (Macdonald, 1949a). The observations to which attention was then drawn have not yet been independently confirmed. They may be summarised here. In living hyphae of some basidiomycetes, nuclei are clearly seen with phase contrast only when closely associated with clamp connexions which are in process of formation. That is, they differ markedly in refractive index from the general cytoplasm only when they are about to divide, are dividing, or have just completed division. Successful staining of the nuclei by the Feulgen method takes place only at these times. At other times, the body which corresponds in position with the nucleus is largely Feulgen-negative, and motile, Feulgen-positive granules are present in the cytoplasm. The theory based on these observations may be re-stated now in a more explicit form. Chemical entities (of which groups of molecules of desoxyribose nucleic acid are the example pin-pointed by the Feulgen test) which form part of the nucleus at the time of its division, pass from the nucleus to the cytoplasm in the periods between nuclear division and carry out there those cell functions which are directly under nuclear control. They are the genes which control cell activities such as wall building. The control of cell activity at points removed from the nucleus is very difficult to understand unless a hypothesis such as this is accepted. That the mechanism of this control is a phenomenon difficult to explain is made abundantly clear when one considers the specific example of the apical cell of the hypha of a basidiomycete fungus such as *Marasmius androsaceus* in which growth in length is restricted to the terminal 10μ of the hypha, yet the nearest nucleus frequently is found about 100μ behind the hyphal tip. The most obvious cell activity here—formation of new wall—is being remotely-controlled, unless one accepts the theory that a physical connection built up of chains of molecules exists within the cell.

Mitochondria are of general occurrence in fungus cells. In different fungi and in the same fungus under different conditions they have been described by the terms "granule", "sphere", "rod", "dumb-bell", "filament", "spiral filament", "thread-like". Steiner (1954) noted that in *Oospora* they were often in pairs and he thought that they multiplied by longitudinal division. Ajello (1948) considered that the nuclear cap in *Polychytrium* might be mitochondrial in origin. Bautz (1955) thinks it probable that there are two distinct types of mitochondria present in higher fungi and that they can be distinguished from each other on the basis of shape and staining properties. A size range from 0·7μ up to 30·0μ has been given for mitochondria in *Polystictus versicolor* by Girbardt (1955). He states that spherical forms originate from threads and are a sure sign of ageing or damaged cells. P. Heim (1947) considers that the granular mitochondria are "inactive" in both basidiomycete and ascomycete fungi. I have observed both movement and division of granular mitochondria in *Marasmius androsaceus.*

A respiratory function is usually attributed to mitochondria. They are generally accepted as being those cytoplasmic bodies which stain with Janus Green B (Martin, 1940). Joyet-Lavergne (1928) demonstrated in *Saprolegnia* the strong reducing and oxidising powers of the "chondriosomes"—their surface appeared to be the seat of a molecular activation playing a role in oxidation, and active hydrogen was present at the surface of the chondriome. Mudd et al. (1951) showed that in yeast the cytoplasmic granules gave indicator reactions for oxidative-reductive enzymes.

Ritchie (1947) was unable to separate the mitochondria of *Allomyces* by centrifuging; but they can be isolated for test by this means. Andresen and Pollock (1952) found in the myxomycete *Physarum* only two types of granules. The mitochondria migrated with the nuclei to the centripetal pole, while yellow-pigment granules went to the centrifugal pole. Centrifugation of *Saccharomyces* by Roll (1955) gave two fractions with granules. Cytochrome oxidase was associated only with the smaller granules.

Ritchie and Hazeltine (1953) with *Allomyces,* Seyfarth (1952a, b) with *Monilia,* Hartman and Liu (1953) and Ephrussi and Slonimski (1955) with *Saccharomyces* all stress the necessity of reserving the name mitochondria for cytoplasmic structures reacting in the same way to certain fixatives and stains, notably to the vital stain Janus Green B. Ephrussi and Slonimski hold the view that the mitochondria carry the respiratory enzyme cytochrome c oxidase, as indicated by the Janus Green B reaction. Slonimski (1953) and Slonimski and Ephrussi (1949) showed that normal and respiration-deficient mutant cultures of yeast could be distinguished by their spectra. The respiration-deficient culture had two absorption bands missing (cytochromes a and b) which were present in normal cultures which contained the respiratory enzymes, succinic dehydrogenase and cytochrome oxidase. Hartman and Liu (1953) and Yotsuyanagi (1955) showed that respiration deficient, mutant strains of *Saccharomyces* gave some positive tests for mitochondria but not the Janus Green B test. Yotsuyanagi interpreted this as meaning that the mitochondria were still present but had lost the respiratory enzyme, cytochrome c oxidase. Mundkur (1953) thought that the explanation of these respiratory mutants was linked with the number and nature of the mitochondria migrating into the bud. One invariably went in and could be followed by others. The average number per cell was six.

P. Heim (1946, 1947, 1948) has traced the development of carotine by mitochondria. The granular mitochondria are said to be in "l'état de repos fonctionnel". At the moment of their activity in the elaboration of the pigment carotine, those which so function become long, thready, more or less thickened and vesiculose. This is demonstrated for *Lysurus, Mutinus, Pseudocolus, Clathrus* and *Ithyphallus.* In *Clavaria,* R. Heim (1949) demonstrated that the pigment is present as carotine crystals in the mitochondria. Carotine is a pigment of particular interest because of the suggestions which have been made and refuted (see Burnett, 1956a) that there is a connection between its occurrence and sexual reproduction in fungi.

If one accepts the evidence for the existence of intracellular granules of variable size but exact function in carrying respiratory enzymes and controlling pigment production, it is surely reasonable to postulate the existence of other, possibly sub-microscopic particles in the cytoplasm which have as exact a function in relation to other cell processes e.g. wall formation. This would also require them to act as carriers of the appropriate enzyme or enzymes. The presence of these particles may yet be proved by the use of chemical methods still to be developed.

Zalokar and Cochrane (1956) have brought forward evidence pointing to the localisation of the enzyme diphosphopyridine nucleotidase in or near the boundary of the spore in *Neurospora crassa.* There is strong support for the theory that the enzymes are formed by individual genes. Lindegren and Lindegren (1956) have identified 8 genes controlling the presence or absence of carbohydrate fermentation in *Saccharomyces.* One gene (MZ) has at least 5 different manifestations involving its ability to respond to 5 different carbohydrate inducers for the production of a single enzyme. The gene DX controls the fermentation of dextrin and glycogen, the gene ST controls the formation of starch, and so on. Marquardt (1952) accepts the theory that enzymes are formed by individual genes; those enzymes requiring association with certain units of the cytoplasm before they become active. These are the units which have been called "plasmagenes". Marquardt regards this as a misnomer because of the differences in their function and reproductive behaviour as compared with nuclear genes. Lindegren (1953), as a result of his work on *Saccharomyces,* claims that his experiments suggest that the gene operates by bearing a great number of transferable elements which lie in a ring round the chromosome. Special genes are considered to be mirror images of the substrate. The study of a multiple allelic series of an enzyme-template gene led to the conclusion that the gene is not the enzyme itself, but acts as a receptor centre which is activated under the influence of the substrate. This results in the formation of the enzyme. Later, Lindegren (1955) suggested that genes may be plastic material attached to desoxyribose nucleic acid, the basic functions of which are to hold the plastic gene in place and to transmit information from it to a functioning cell centre.

The conduct of breeding experiments on a mathematical basis and the use of the data obtained to interpret the constitution and potentialities of the parent stocks have given a much fuller understanding of population genetics and of the mating systems which occur in fungi (see Burnett, 1956b). As one result, characters such as increased ability to ferment sugar or to produce antibiotics can be and are being bred into suitable races of appropriate fungus species.

The fungi, by reason of their short life histories and relative ease of culture, are material peculiarly suitable for cytogenetic examination and, once their nuclear content has been determined, for experiments designed to subject their chromosomes to mutagenic agents with a view to inducing mutations of practical importance. The two genera most used to adduce evidence of the potential practical value of this type of investigation are *Neurospora* and *Saccharomyces*. It would seem that some of the species which have been most completely studied might well be used in assaying the radiation effects produced in nuclear explosions. It ought to be a comparatively simple matter—for a geneticist—to draw up a table of dosage and resultant mutation effect, using standard races of a standard fungus. Thereafter, a competent technician could study the exposed cells or colonies and produce the necessary answer on degree of contamination.

Backus and Stauffer (1955) have produced, with the aid of mutagens such as ultraviolet radiation, strains of *Penicillium chrysogenum* showing improved ability to produce penicillin. Boone et al. (1956) have used ultraviolet light and nitrogen mustard in their work on *Venturia inaequalis* to produce colonies showing morphological, colour differences e.g. green, white, pink, yellow colonies; or biochemical mutants e.g. colonies deficient for biotin or for nicotinic acid. A parasite such as this species of *Venturia* might well be controlled in future by a mutagen inducing the large-scale production of a biochemical mutant with a very much reduced or even negligible chance of survival.

The influence of the cell products of one fungus on the development of another has been nicely illustrated by Buston and Khan (1956). When *Aspergillus fumigatus* grew in association with *Chaetomium globosum* certain metabolic products of the former diffused from the cell to the medium and stimulated localised formation of perithecia by *Chaetomium*. Another side of the picture is exposed by Kirkham and Flood (1956) who have brought about the inhibition of growth of *Venturia* spp. by analogues of host metabolites e.g. cinnamic acid, thereby illustrating a valuable line of approach to the development of new fungicides of exact action. Bryde et al. (1956) have recently published an account of the effect of fungicides on fungus enzymes.

Among the results accruing from the long series of studies on the *Physiology of Parasitism* carried out at Imperial College, those most recently published by Cole (1956), Singh and Wood (1956) and Gupta (1956) suggest that, in the case of the parasitic fungi investigated, the host tissue-attacking enzymes are produced in response to the presence of natural extracts from the host or specific chemicals present in the host cells. Turner (1956) has demonstrated the inhibition of growth and respiration in *Ophiobolus graminis* and its variety *avenae* by stated concentrations of a partially-purified, but unidentified substance from oat-leaf sap. The inhibitor prevented the growth of nearly half of over 40 fungi tested. The organisms belonged to all the major groups. This type of thinking indicates how in future parasitic fungi may come to be destroyed by fungicidal attack aimed deliberately at one vital fungus enzyme, or at one gene necessary for the development of that enzyme.

Attacks aimed at the metabolism of the cell have been used to increase chosen products of fungus metabolism. Thus, Chesters and Rolinson (1951) working on the part played by zinc in the utilization of carbohydrate by *Aspergillus niger* showed that cultures partially deficient in zinc or in a range of other metals yielded increased percentages of organic acids. Yemm and Folkes (1954) showed that increased respiration rate i.e. increased rate of breakdown of carbohydrates, occurred in food yeast, *Torulopsis utilis*, with the removal of nitrogen-deficiency in the yeast cells. This type of investigation stresses the interdependence of the different physiological processes going on within the same fungus cell.

Dr. Hawker's work, "The Physiology of Reproduction in Fungi", at present in the press will be an interesting addition to the literature on this special field of cell physiology. Two recently published papers have drawn attention respectively to biochemical differences between male and female sex cells and to the activity of so-called sex hormones in the fungi. Chodat and Turian (1955) have found a biochemical difference between gametangia in the two species *Allomyces javanicus* and *A. arbuscula*. If male and female gametangia are vitally stained with Janus Green B a reduction of the dye follows in the lipid granules of the female gametangium. This can not be seen in the male gametangium, the supporting cells or the sterile cells. A very special case of the influence of the content of one cell on another is the "sex hormone" effect. Bistis (1956) has shown that in *Ascobolus stercorarius* induction of ascogonia occurs within about 500μ of a single oidium planted on what was previously a sterile mycelium and that the trichogynes will show directional growth if occurring within about 100μ of such an oidium.

Two quotations from recent writing on plant cells seem to me to be appropriate for inclusion here, though neither refers specifically to the fungi. Darlington (1955) writes: "The cytoplasm exerts its short term control over the nucleus not as a rule by changing the composition of the chromosomes, for such changes are irreversible, but by feeding them with materials which either stimulate the activity of certain genes, or provide for the reproduction of all of them. In regard to these two alternatives the cytoplasm differs at the two ends of any cell the products of which are going to follow a different course of development. Similarly, the initiation of meiosis in the nucleus, ... must arise from a sudden [biochemical] change in the cytoplasm". Steward et al. (1956) have observed "Much modern biochemistry is pre-occupied with cellular particles and particulate preparations. However the study of metabolism, in relation to growth, ... requires work on the whole cell to reveal the integrated operation of the whole system".

The examples put before you have been selected in the hope that they may indicate at least some avenues the exploration of which will prove profitable in future research on the fungus cell.

It is my own belief that worthwhile work in mycology in the near future, whether it is without obvious practical application or is aimed at the conquest of problems in pathology or in commercial nutrition, must be trained on the discovery of the minute structure and detailed functioning of the fungus cell, working ever closer to molecular level.

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THE FLORA OF UNST, SHETLAND, IN RELATION TO THE GEOLOGY.

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INTRODUCTION.

The Shetland Islands lie 200 miles west of Bergen in Norway and about 105 miles from Duncansby Head on the Scottish mainland. At their north end is Unst. The island is 12 miles long from north to south and 5 miles wide, with a land surface of 29,866 acres. It has a varied geology of acid gneisses and mica-schists, basic greenstones and ultrabasic serpentine.

The vegetation of the serpentine can be seen even from a distance to differ markedly from that of the adjoining acid rocks. It was Edmondston (1845) who first, if briefly, noted qualitative differences in the floras of the contrasted rock types. There are some comparisons too in a preliminary account of the vegetation of Unst by West (1912). The object of the present paper is to demonstrate these differences quantitatively.

Rune (1953) finds the feature of its flora differing markedly from that of neighbouring rocks typical of serpentine at least in northern areas. Characteristic too are areas almost bare of plants, and the presence of species with discontinuous distributions. Both of these phenomena occur in Unst. There is extensive sparsely colonised debris, composed of small angular fragments about 2 cm. in diameter, to which several more or less rare species are confined.

All these features are examples of the 'serpentine effect' (Rune, 1953). In a paper by the present writer (Spence, 1957), the effect on vegetation in Unst is examined both of the peculiar nature of serpentine soil and of the climate, which is in some respects extreme for Britain because of Shetland's northerly position. In a second paper, study is made of the cause of the restriction of rare species to pioneer habitats. In the present account, therefore, data on climate and soils are reduced to the necessary minimum. Fuller information is supplied at appropriate points in the other papers.

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Climate.—To an altitude of 1000 ft. (305 m.), which includes all Unst, Shetland has a submontane-oceanic climate; its mean monthly temperatures during the growing season (roughly 42° F. and over) being equivalent to those found at 1176-2500 ft. (359-762 m.) in the central Highlands. Winds are strong; at 800 ft. (244 m.) on a hilltop in West Mainland, Shetland, the mean annual windsweep of 23 m.p.h. is four-fifths that on the summit of Ben Nevis at 4416 ft. (1343 m.) (data from Spence, 1957).

Geology and Soils.—The block of gneisses forming the western part of Unst is dominated by the strike ridge of Vallafield (=fell). Averaging 500 ft. (152 m.) in height, this runs north for seven miles to end in Hermaness. The gneisses are bound to the east by the valley that runs north-south from Burrafirth to Belmont. This valley is the western boundary of the block of mica-schists which reaches its highest point in Saxavord (960 ft.: 293 m.), east of Hermaness. The block persists in a thin line down the valley. A belt of schists (Muness phyllites) forms most of the south-east peninsula of the island (Read, 1936). Excepting sea-cliffs and some of the steepest slopes, practically all the gneiss and mica-schist exposure is covered in deep peat (blanket-bog).

South of the mica-schist and east of the Burrafirth-Belmont valley lies the igneous intrusion of basic and ultrabasic rocks (Read, 1936). Gently sloping like the other rocks, the basic greenstone is mainly covered in thin, wet, anaerobic raw humus but there is no accumulation as deep peat (some, however, may be peat-cleared ground). On the north-south summits of Colvadale and Sobul (400 ft.: 122 m.) there is coarse debris covered by *Rhacomitrium*-heath.

The ultrabasic or serpentine block does not exceed 500 ft. (152 m.) in altitude. The rocks of the block are well exposed and there is much sparsely colonised debris. Most of the serpentine area, however, is covered by closed vegetation, under which the soil is thin and fine. This soil has apparently originated *in situ* and is covered by little or no mor (aerobic raw humus). Anaerobic raw humus, either in a thin layer or accumulated as peat, is absent. Soil-pH on serpentine varies from 8·10-6·20 on mire soils, 6·92-6·32 on mineral debris with sparse plant cover, to 5·50-5·12 under heath vegetation (data for serpentine from Spence, 1957).

METHODS.

The vegetation can be grouped broadly as cultivated and permanent pasture land, sand dune, sea-cliff and hydrophytic vegetation: and the rest, which I call hill-land. The object of the investigation was to give the frequency of any species on each rock type. Samples had therefore to be limited to areas where the nature of the rock determined the soil type rather than for example the sea, as on sea-cliff and its neighbourhood, or topography, as in valley-bogs. Quantitative investigation was therefore confined to hill-land, to the communities of blanket-bog of the acid rocks and the heath, etc., of greenstone and serpentine.

Raunkiaer's method of frequency estimation was used with a quadrat size of 1 sq. ft. (0·1 sq. m.) (Raunkiaer, 1934). The vegetation was examined as a whole, each rock type including several plant formations in Raunkiaer's sense. Quadrats were thrown at paced intervals and without regard to communities over well separated areas of vegetation of each rock type; that is, as uniformly as possible over the area (Raunkiaer, 1934). 150 samples were taken on serpentine, 100 on greenstone and 200 and 100 on gneiss and mica-schist respectively. Table I gives the results.

Frequency of a species depends not only on its quantity but also on its distribution. It can be argued that, by using no other quantitative measure in this analysis, accuracy has been sacrificed for speed. But, since it has been used as a means of description only, many of the other criticisms of frequency as summarised by Goodall (1952) do not apply here; I was not, for instance, concerned with additive functions of frequency. The object indeed was to find an approximate answer to the question: "How often is species X encountered in traversing the hill-land of any rock type?" To that limited aim this method seems precisely suited.

THE SPECIES OF HILL-LAND GROUPED ACCORDING TO ROCK PREFERENCE.

The qualitative differences between the distribution of the species on acid, basic and ultrabasic rocks is expressed (Table I) in quantitative terms. The flora may thus be divided into plants which, since I am primarily interested in serpentine, are characteristic of, indifferent to or accidental on, that rock, or absent from it. A means of assigning each species to a group is available: the ratio of the frequency of that species on serpentine to its nearest frequency on another rock. This is a measure of how far that species is exclusive to serpentine. It follows that all species on serpentine having a frequency-ratio greater than unity are indicated as serpentine-characteristic, for, as one speaks of species actually confined to serpentine, it is in this sense rather than in its absolute quantity that a species is 'characteristic'.

There are, however, exceptions to the use of this measure. When a species occurs on more than one rock and never has a high frequency the consequence of sampling error will be considerable. So a frequency of at least 10 per cent. on one rock and exclusiveness, of three or more, to that rock have been thought necessary to assign a species to other than the indifferent group.

With this preamble, the four groups on hill-land may now be defined:

1. SERPENTINE-CHARACTERISTIC. Plants quite exclusive, or having an exclusiveness greater than 2-3 and frequency of more than 10 per cent.
2. SERPENTINE-INDIFFERENT. Plants with exclusiveness about unity and with, therefore, no preference for serpentine *or* other rocks and soils in Unst.
3. SERPENTINE-CASUAL. Plants with exclusiveness to another rock *and* very low frequency on serpentine.
4. ACID-ROCK-CHARACTERISTIC. Plants with exclusiveness to acid rocks *and* absent from serpentine.

As with the degree of fidelity of a species to a community so there may be differences between a species' local and general exclusiveness to, or preference for, serpentine. Serpentine-characteristic is used here in this local sense. The wider or regional preference of a species can only be considered after examination of other serpentine and non-serpentine areas.

TABLE I.

Quantitative list of the flora of the hill-land of Unst, on serpentine (S), greenstone (G) and acid rocks (A). Figures are of % frequency on each rock; + denotes frequency less than 1%. The list is not exhaustive.

1: SERPENTINE-CHARACTERISTIC

1a: *Exclusive Species*

GEOGRAPHICAL TYPE*		S	G	A
	ANTHYLLIS VULNERARIA†	1	—	—
A.S.A.	ARENARIA NORVEGICA	4	—	—
O.N.	ARMERIA MARITIMA	3	—	—
L.A.O.	ASPLENIUM VIRIDE	+	—	—
	A. ADIANTUM NIGRUM	+	—	—
	BOTRYCHIUM LUNARIA	+	—	—
A.A.	CARDAMINOPSIS PETRAEA	1	—	—
A.S.A.	CERASTIUM NIGRESCENS	3	—	—
	COELOGLOSSUM VIRIDE	+	—	—
A.S.A.	COCHLEARIA SCOTICA	+	—	—
A.A.	DRABA INCANA	+	—	—
	EUPHRASIA ROTUNDIFOLIA	3	—	—
	GENTIANELLA CAMPESTRIS	+	—	—
L.A.O.	LYCOPODIUM ALPINUM	1	—	—
A.S.A.	MINUARTIA RUBELLA**	+	—	—
A.A.	POLYGONUM VIVIPARUM	1	—	—
	RHINANTHUS SPADICEUS	1	—	—
N.M.	RUBUS SAXATILIS	1	—	—
	RUMEX ACETOSA	+	—	—
	SAGINA NODOSA	3	—	—
A.A.	S. SAGINOIDES***	+	—	—
	SCHOENUS NIGRICANS	1	—	—
A.A.	SILENE ACAULIS	+	—	—
O.N.	S. MARITIMA	1	—	—
	THELYPTERIS DRYOPTERIS	+	—	—

1b: *Not Exclusive Species*

GEOGRAPHICAL TYPE*		S	G	A
	ACHILLEA MILLEFOLIUM	10	2	—
N.M.	ANTENNARIA DIOICA	39	8	—
	CAREX FLACCA (& C. PANICEA)	86	48	2
	C. PULICARIS	42	25	—
	LINUM CATHARTICUM	55	1	—
	PLANTAGO LANCEOLATA	25	3	—
	P. MARITIMA	87	17	2
	POLYGALA SERPYLLIFOLIA	20	3	—
	PRUNELLA VULGARIS	40	4	—
	SCILLA VERNA	37	10	2
	SELAGINELLA SELAGINOIDES	50	11	+
	SUCCISA PRATENSIS	45	6	6
A.A.	THALICTRUM ALPINUM	52	2	—
O.N.	THYMUS DRUCEI	86	16	3
	VIOLA RIVINIANA	53	25	6

Geographical Type*	2: Serpentine-indifferent	S	G	A
	Agrostis canina & A. stolonifera	65	54	21
	Anthoxanthum odoratum	4	2	39
	Bellis perennis	1	+	+
	Calluna vulgaris	82	70	76
	Carex demissa	2	5	—
	C. dioica	1	+	+
	C. nigra	+	+	1
	Cerastium tetrandrum	1	+	+
	C. vulgatum	7	+	7
	Euphrasia ? curta var. piccola	+	—	—
	E. foulaensis	+	—	+
	E. micrantha	+	+	—
	Festuca rubra & F. vivipara	69	56	19
	Holcus lanatus	2	+	3
	Jasione montana	+	+	2
	Hypericum pulchrum	8	13	1
	Leontodon autumnale	8	3	4
	Lotus corniculatus	5	+	2
	Lycopodium selago	1	+	+
	Molinia caerulea	60	50	36
	Orchis ericetorum	1	+	+
	Pinguicula vulgaris	3	2	2
	Polypodium vulgare	+	+	1
	Polygala vulgaris	5	+	+
	Potentilla erecta	88	75	66
	Ranunculus flammula	+	1	+
	R. acris	+	+	1
	Rhinanthus minor s.s.	2	+	1
	Salix repens	+	+	1
	Sagina procumbens	2	+	2
	Sieglingia decumbens	44	36	12
	Trifolium repens	7	+	1
	T. pratense	1	1	+
	Viola canina	3	1	1

3: Serpentine-casual

	S	G	A
Carex binervis	2	29	10
C. pilulifera	1		
Deschampsia flexuosa	1	2	11
Dryopteris dilatata & D. filix-mas	1	+	2
Erica cinerea	1	38	3
E. tetralix	5	33	11
Luzula multiflora	8	6	30
Nardus stricta	9	66	50
Narthecium ossifragum	2	33	7
Pedicularis sylvatica	+	+	1
Rhacomitrium lanuginosum	5	63	16
Trichophorum caespitosum	+	48	34
Vaccinium myrtillus	+	—	10

GEOGRAPHICAL TYPE*	4: ACID-ROCK-CHARACTERISTIC	S	G	A
	BLECHNUM SPICANT	—	+	2
	CAREX STELLULATA	—	+	2
A.A.	C. BIGELOWII	—	+	+
	POTENTILLA PALUSTRIS	—	—	+
	DROSERA ROTUNDIFOLIA	—	2	2
	EMPETRUM HERMAPHRODITUM	—	4	48
	ERIOPHORUM ANGUSTIFOLIUM	—	6	70
	E. VAGINATUM	—	1	5
	GALIUM HERCYNICUM	—	7	9
	HYDROCOTYLE VULGARIS	—	—	1
	JUNCUS SQUARROSUS	—	5	32
	LUZULA SYLVATICA	—	—	7
	MELAMPYRUM PRATENSE***	—	—	+
	PTERIDIUM AQUILINUM	—	—	1
A.A.	SALIX HERBACEA	—	—	+
	SOLIDAGO VIRGAUREA	—	—	+
N.M.	TRIENTALIS EUROPAEA	—	—	+
A.A.	VACCINIUM ULIGINOSUM	—	—	4

*A.A., arctic-alpine; A.S.A., arctic-subarctic; L.A.O., low arctic-oceanic; N.M., northern montane; O.N., oceanic northern. (Matthews, 1937, 1955; Böcher, 1954.)

†Nomenclature according to Clapham, Tutin and Warburg (1952).

**Beeby (1887) in Druce (1922).

***Druce (1922).

SUMMARY OF COMMUNITIES OF HILL-LAND.

The major communities in the predominant blanket-bog of the acid rocks are:—

(1) *Eriophorum angustifolium* co-dominant with *Calluna vulgaris* and *Empetrum hermaphroditum*; *Trichophorum caespitosum* and *Rhacomitrium lanuginosum* are abundant. The number of species per 1 sq. ft. (species density) is lowest here. The community occurs on deep undisturbed peat with much cutting back.

(2) *Calluna-acid* grassland; any or all species of (1) with any from the following community. Its distribution is sometimes ecotonal.

(3) *Nardus stricta-Juncus squarrosus* (acid grassland). The dominant or subdominant species of (1) drop in quantity while species density increases. The community occurs widely on naturally or artificially drained ground and redistributed peat.

(4) *Vaccinium*-acid grassland; differs from (2) mainly in the replacement of *Calluna* by *Vaccinium myrtillus* or *V. uliginosum* and an increase in *Luzula sylvatica* This is a summit community, in which *Trientalis europeaus* occurs, and is of smaller extent than the others.

On greenstone, the coarse debris of the flat summits is covered by *Rhacomitrium*-heath. *Nardus stricta-Juncus squarrosus* (acid grassland) occupies the thin wet raw humus on most of the rest of the outcrop. The latter community is an impoverished version of that (3) occurring on the blanket-bog. *Erica cinerea* (heath) is found locally on free-draining soil.

On serpentine the vegetation comprises:—

(1) *Arenaria norvegica-Cardaminopsis petraea* community on debris having sparse plant cover.

(2) *Carex flacca-C. pulicaris-Festuca* species (sedge-grass) and *Calluna-Erica cinerea* (heath) communities on free-draining soils.

(3) *Carex flacca-C. demissa* and *Schoenus nigricans-Molinia caerulea* communities on mire soils.

(4) *Asplenium viride* community on rock crevices.

ANALYSIS OF SPECIES DISTRIBUTION.

There are 40 serpentine-characteristic species. Within that group most of the species, exclusive on hill-land to serpentine, are confined to debris; e.g. *Arenaria norvegica, Cerastium nigrescens, Cochlearia scotica, Rubus saxatilis* and *Sagina nodosa*; or to debris and crevices, as *Cardaminopsis petraea*; or to crevices alone, like *Draba incana, Asplenium adiantum-nigrum, A. viride* and *Thelypteris dryopteris*. There are two other species which I have not seen but which have their only recorded Shetland localities on this debris, namely *Minuartia rubella* in "stony places on serpentine, Wick of Hagdale" (Beeby, 1887, in Druce, 1922) and *Sagina saginoides,* recorded from the Muckle Heog by Druce (1922). Both records are accepted by Clapham, Tutin and Warburg (1952). *Schoenus nigricans* occurs in mire soils, *Polygonum viviparum* and *Lycopodium alpinum* on heath, while *Rhinanthus spadiceus* and *Euphrasia rotundifolia* are found on heath or debris. These 17 species, out of 25 exclusive on hill-land to serpentine, are also restricted, over *all* habitats in Unst, to serpentine.

The remaining 8 species are also found on sea-cliffs of any rock type or sand dunes or, in one case, cultivated ground. Thus *Anthyllis vulneraria, Armeria maritima, Silene maritima, S* *caulis* and *Rumex acetosa* grow on serpentine debris, or sea-cliff if any rock type. *Rumex acetosa* also occurs on cultivated ground and *S. acaulis* on serpentine heath. *Botrychium lunaria, Coeloglossum viride* and *Gentianella campestris* appear on serpentine debris which has passed the primary stage of colonisation, in the serpentine sedge-grass community and in sand dunes.

The other serpentine-characteristic species are all widespread on serpentine. *Carex flacca, Thymus drucei, Plantago maritima, Linum catharticum* and *Thalictrum alpinum* being typical of the closed vegetation. Their exclusiveness varies from 2 (*Carex flacca*) to more than 50 (*Linum catharticum*).

It is noted that 22 out of 108, or 20% of the species of Unst hill-land listed in Table I are arctic-alpine, arctic-subarctic, northern montane or oceanic northern species (Matthews, 1937, 1955) or low arctic-oceanic (Böcher, 1954). Of these, the majority (17 out of 22) are serpentine-characteristic, 11, or 50% being confined there entirely or partially to debris or crevices. Most of these boreal species have more or less discontinuous distributions in this part of their range. They are thus of the floristic element stated by Rune (1953) to be a feature of serpentine vegetation in northern areas.

There is a large group of serpentine-indifferent species; nor is the list in Table I exhaustive. Some have high frequencies on both acid and ultrabasic rocks. *Festuca* species or *Calluna* dominating characteristic communities.

In the serpentine-casual group *Erica cinerea* and *Rhacomitrium lanuginosum* have their highest frequency on greenstone. Rarely present on serpentine are one or two dominants on acid rocks in Unst like *Vaccinium myrtillus* or *Trichophorum caespitosum*, and several others such as *Carex pilulifera* and *Deschampsia flexuosa* which occur in the blanket-bog communities on these latter rocks. Finally, *Empetrum hermaphroditum, Eriophorum vaginatum, Drosera rotundifolia* and *Rumex acetosella* are quite absent from serpentine. All this may reflect the relatively high soil-pH (5·12) recorded even on serpentine heath for, apart from *Deschampsia flexuosa* (soil-pH range 3·5 to 5·4, in Scurfield, 1954), *Rhacomitrium lanuginosum* and *Erica cinerea*, all these species are known acidiphils. An acidiphil (Small, 1946) has a soil-pH range of from less than 4·8 to 5·2. (The data for *Vaccinium* and *Trichophorum* are taken from Hora (1947), the remainder from Small (1946).) There are other species absent from serpentine which are widespread in raw humus habitats — *Eriophorum angustifolium, Luzula sylvatica* and *Juncus squarrosus,* or oligotrophic bog species like *Potentilla palustris* and *Hydrocotyle vulgaris.* The rarities on and absentees from serpentine are abundant in blanket-bog and other raw humus, acid habitats.

The ultrabasic block has either a mineral soil or one bearing thin mor. Peat is absent. Greenstone has some mineral soil and mor but is covered mainly in thin wet raw humus. Mor occurs on a few steep slopes of the gneiss and mica-schist exposures which are otherwise covered in the deep peat of blanket-bog. The distribution and depth of the different types of raw humus indicates that the range ultrabasic, basic and acid rocks in Unst forms a series with increasingly poor drainage. Differences in the species lists from each rock type can be attributed primarily to variations in depth and type of humus on the three rocks, allowing more, or less, contact with the mineral substrate. The chemical nature of the substrate can substantially affect only the serpentine flora, and the peat-free, often entirely mineral, serpentine soil harbours 75 per cent of the boreal species. The soil and vegetation of Unst thus follow a trend from the ultrabasic mineral debris with its exclusive species, via the thin mor on serpentine, which lacks acidiphils and many other species typical of raw humus, to the generally deep peat over the acid rock with *its* exclusive species.

SUMMARY.

The species forming the flora of Unst hill-land are grouped according to their frequency on different rocks and comprise serpentine-characteristic, serpentine-indifferent, serpentine-casual and acid-rock-characteristic species. Their distribution varies with decrease in drainage and increase in raw humus accumulation in the series ultrabasic, basic and acid rocks.

17 out of the 22 boreal species in Unst are serpentine-characteristic. 11 of the 22 of them are more or less exclusive to sparsely colonised debris, or crevices, on that rock. Many have discontinuous distributions. The presence of such species and poorly colonised ground are normal features of vegetation on serpentine in northern areas

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NOTES ON ALGAE FROM THE PLANKTON OF SOME SCOTTISH FRESHWATER LOCHS.

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The following notes deal with algae which have been found in collections of phytoplankton taken with a tow net of 180 meshes to the inch. Most of the algae considered are new records for Scotland and a number do not seem to have been found previously in the British Isles. The locality of each loch mentioned is indicated by the full National Grid Reference, given after it is named in the text for the first time.

CHLOROPHYCEAE.

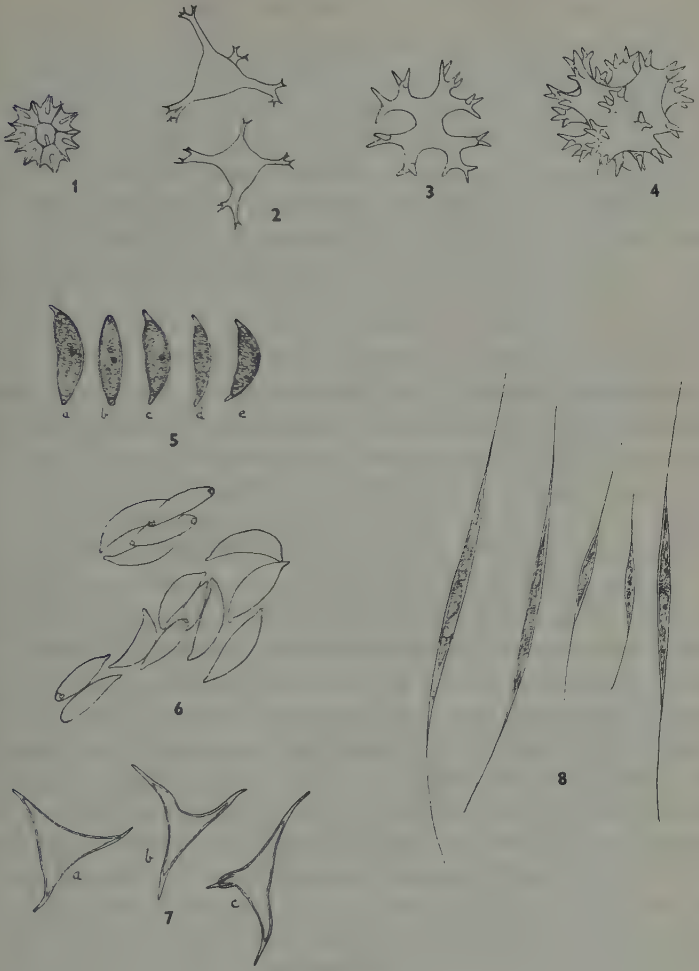
CHLOROCOCCALES.

1. PEDIASTRUM TETRAS var. TETRAÖDON (Corda) Rabenh. (Text-fig. 1, 1).

Specimens of this variety have been found in summer samples of plankton from Loch Moraig, Perthshire (27/908666). The coenobia are always 8-celled and the outer margins of the seven peripheral cells are very deeply incised. The resulting lobes are further divided to form sharply pointed, divergent, horn-like processes, which in the present material tend to overlap the adjacent cells. Marginal cells 6-8μ l., 4-6μ br., coenobia 20-25μ diam.

2. TETRAEDRON PLANCTONICUM G. M. Smith (Text-fig. 1, 2).

This rather delicate *Tetraedron* species occurred in small numbers in the late summer plankton of the eutrophic Lindores Loch, Fife (37/265165). The cells, which are polyhedral-pyramidate with 4 or 5 angles, have distinctly convex sides while the angles are produced to form slender, more or less parallel-sided, furcate processes, each furca being tipped with 2, or more rarely 3, delicate, divergent spines. These plants seem to be more slender than the American forms of this species (Smith 1922, Prescott 1951) and were it not for the fact that the processes are distinctly branched, they could be referred to *T. hastatum* var. *palatinum* (Schmidle) Lemm. Cells 15μ diam. without processes; 30-40μ diam. with processes.



Text-fig. 1.

1. Pediastrum tetras var. tetraodon (Corda) Rabenh.
2. Tetraedron planctonicum G. M. Smith
3. Tetraedron gracile Borge
4. Tetraedron enorme (Ralfs) Hansg.
5. Tetraedron lunula (Reinsch) Wille
6. Tetraedron lunula (Reinsch) Wille
7. Tetraedron trigonum var. gracile (Reinsch) De Toni
8. Ankistrodesmus acicularis (A. Br.) Skuja

3. TETRAEDRON GRACILE Borge (Text-fig. 1, 3).

A much more robust form of this species than that previously described from Sutherland (Brook 1957), but still with the very characteristic twice branched angles of its cells all lying in the same plane but at an angle of 90° to one another, has been found in net hauls from Ridge Loch, Sutherland (29/335332). It differs from these previously described Scottish specimens in that the forked spines, with which the processes are tipped, are much stouter and not all lying in the same plane as the body of the cell.

4. TETRAEDRON ENORME (Ralfs) Hansg. (Text-fig. 1, 4).

Considerable numbers of this species, the angles of whose polyhedric cells are produced to form short bifurcate lobes terminating in pairs of stout spines, were present in small pools near Loch Bhac, Perthshire (27/822622). Cells up to 50μ br.

5. TETRAEDRON LUNULA (Reinsch) Wille (Text-figs. 1, 5, a-e; 1, 6).

This species, which does not seem to have been recorded before from Britain, has been found in considerable amounts in plankton hauls from Loch na Craige, Perthshire (27/883455) and Loch Spynie, Morayshire (38/257665) in June and July. The cells are typically lunate and taper to distinctive poles which may be blunt or quite sharply pointed. Their outer margins in side view are more sharply curved than the inner, which may in some cases (Text fig. 1, 5 a, c and d) have a marked depression in the centre. In face view (Text fig. 1, 5 b), the sides of the cells show more or less equal curvature. In the material from Loch na Craige the cells tended to remain in groups of four, each group, it is presumed, having developed from four autospores liberated from a single parent cell. Cells 25-30μ l., 5-8μ br.

6. TETRAEDRON TRIGONUM var. GRACILE (Reinsch) De Toni (Text-fig. 1, 7, a-c).

Occasional specimens of this variety, whose cells have very delicate cell walls and can thus be easily overlooked, especially in preserved material where the colour has faded from the chloroplasts, have been found in the plankton of Loch Calder, Caithness (39/670610). The cells are usually flat, the slender, considerably produced, tapering angles of which terminate in a sharp spine, all tend to lie in the same plane. In some specimens the angles are markedly curved and the sides of the cells extremely concave (Text-fig. 1, 7 b). Diameter, including spines, 35-40μ.

7. ANKISTRODESMUS ACICULARIS (A. Br.) Skuja (Text-fig. 1, 8).

The solitary, fusiform cells of this species which may be straight, slightly curved or sigmoid, with their characteristic long and finely drawn-out apices, were common in the plankton of Loch na Beiste Brice, Sutherland (29/238501). The illustrations of this alga in West and Fritsch (1931, Fig. 40 B and C), where it is referred to as the var. *acicularis* (A. Br.) G. S. West of *Ankistrodesmus falcatus* (Corda) Ralfs, do not seem to represent it adequately, for the finely hair-like, attenuated, apices are not shown, and, in fact, there would seem to be little difference between these figures and those depicting the var. *mirabilis* W. & G. S. West (West and Fritsch *loc. cit.* Fig. 40D). The size of the Loch na Beiste Brice cells was very variable, ranging from 50μ l. and 2·5μ br. in the case of young cells, to 125μ l. and 4μ br. in old cells just before division.

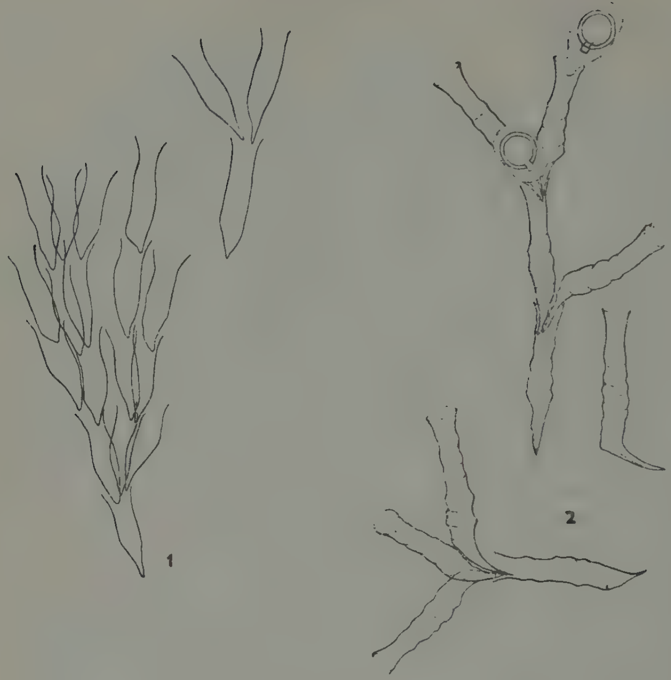
CHRYSOPHYCEAE.

1. DINOBRYON CYLINDRICUM var. ALPINUM (Imhof) Bachm. (Text-fig. 2, 1).

This variety, which seems to be intermediate in character between its type species and *D. sertularia* Ehr. and which has not been previously recorded from Scotland, was frequent in the spring plankton of the Ridge Loch, Sutherland. The envelopes, which vary in size from 45-55μ l. and 10-11·5μ br., are arranged in much more compact colonies than the type species.

2. DINOBRYON DIVERGENS var. SCHAUINSLANDII (Lemm.) Brun. (Text-fig. 2, 2).

This variety of *D. divergens* Imhof, is fairly widely distributed in the plankton of meso-oligotrophic Scottish lochs. Some particularly fine colonies have been found in a sample from Loch Meadie, Sutherland (29/402645) with unusually long, though typically undulate envelopes of up to 75μ l. Their breadth varied from 9-12·5μ. A considerable number of the envelopes bore cysts within characteristic membranes, 25μ l. and 20μ br., just outside the aperture of the envelope. The cysts themselves, which are spherical, were of larger size than those noted by Huber-Pestallozi (1941, p. 229), being 17·5μ in diameter.



Text-fig. 2.

1. Dinobryon cylindricum var. alpinum (Imhof) Bachm.
2. Dinobryon divergens var. schauinslandii (Lemm.) Brun.

CYANOPHYCEAE.

1. Marsoniella elegans Lemm. (Text-fig. 3, 1).

This small blue-green alga, previously unrecorded from the British Isles, has been frequent at times in the early summer plankton of Loch Moraig, Perthshire. The colonies were usually of only 4 or 8 pyriform cells, sometimes slightly curved and radiately arranged with their broad ends directed inwards. These groups of cells are enclosed within a transparent mucilage envelope which usually can only be seen by staining or by mounting in Indian ink. Cells 2-2·5μ br., 6-7μ l. Colonies, without mucilage investment 15μ diam., with mucilage 25μ diam.

2. DACTYLOCOCCOPSIS ACICULARIS Lemm. (Text-fig. 3, 2).

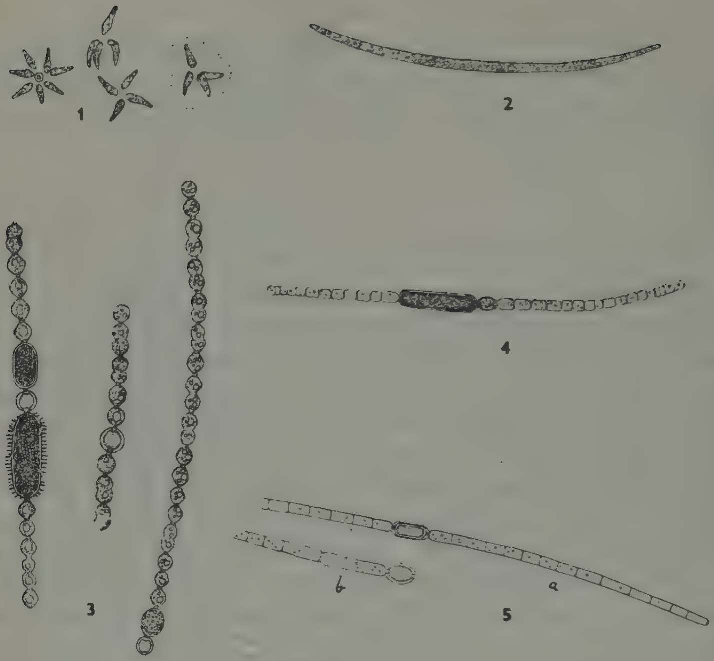
Unusually long specimens of this species, which thus resemble the var. *grandis* Fremy, have been found in the plankton of the Hill Park Lochan, nr. Kenmore, Perthshire (27/802432). Cells 160μ l., 3·7μ br.

3. ANABAENA ECHINOSPORA Skuja (Text-fig. 3, 3).

Filaments of this alga, which is a new record for Scotland, have been found in plankton samples from Loch Monzievaird, Perthshire (27/842233) and Loch Watten, Caithness (39/230560), both of which are distinctly alkaline waters, the pH and alkalinity, when the plankton hauls were taken, being 8·0 and 60 p.p.m. $CaCO_3$ and 9·3 and 61·2 p.p.m. $CaCO_3$, respectively. The solitary trichomes are straight, or only slightly curved, and consist of spherical or occasionally somewhat angular cells, mostly about 8μ br. The heterocysts are also spherical and of approximately the same diameter as the vegetative cells. The spores, which develop on each side of the heterocysts, are cylindrical, with rounded ends, and those found in these Scottish samples did not exceed 40μ l. and 13μ br. The spores when mature are decorated with a dense cover of short colourless spines (extruded mucilage?).

4. ANABAENA CYLINDRICA Lemm. (Text-fig. 3, 4).

A few trichomes of this blue green alga have been found from time to time in plankton samples from Loch na Beiste Brice. They are composed of series of cylindrical cells with broadly rounded ends, those at either end being smaller than the cells in the middle region of the trichome thus giving it a tapered appearance. The free end of each terminal cell is rounded. The broadest cells in the central region are never more than 5μ in width and up to 7·5μ long, while those at the ends taper to 3μ in breadth. The heterocysts are ovoid and of about the same dimensions as neighbouring cells, being 5μ br. and 7·5μ l. Each heterocyst is surrounded by a wide, colourless mucilage envelope, while the spores which develop adjacent to the heterocysts are cylindrical and slightly broader than the other parts of the trichome (usually 6-7μ) and up to 25μ l.



TEXT-FIG. 3.

1. MARSONIELLA ELEGANS Lemm.
2. DACTYLOCOCCOPSIS ACICULARIS Lemm.
3. ANABAENA ECHINOSPORA Skuja
4. ANABAENA CYLINDRICA Lemm.
5. ANABAENA SUBCYLINDRICA Borge

5. ANABAENA SUBCYLINDRICA Borge (Text-fig. 3, 5 a and b).

According to Geitler (1932) there is little reason to separate this species from the above mentioned *A. cylindrica*. Borge's figures (see Huber-Pestallozi 1938, Abb. 124), however, show distinct differences in the shape of the cells and heterocysts and in the character of the spores. Specimens of an *Anabaena* species which can only be referred to this species have been found in the plankton of the middle loch of the Lochan nan Ealachan group of lochs, Sutherland (29/328346). In these, the cells which form the straight, slightly tapering trichomes are distinctly rectangular, with only very slight constrictions between each cell. Their breadth varies between 4-5·5μ from the end to middle of each trichome and their length from 5-8μ. The heterocysts, which are of about the same width as the vegetative cells, are surrounded by a narrow colourless envelope, their width and length being 6μ and 12μ respectively. Occasional trichomes have been observed (Text-fig. 3, 5 b) in which there are terminal heterocysts, oval in shape and thus differing radically from those which must be regarded as typical. No spores were observed.

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AN ECOLOGICAL STUDY OF THE LAMINARIACEAE OF AILSA CRAIG, HOLY ISLAND, INCHMARNOCK, MAY ISLAND, AND SEAFORTH ISLAND.

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INTRODUCTION.

A survey of the Laminariaceae growing around the coast of Scotland and its Islands (over 6,000 miles long) was in continuous operation from 1946 to 1956. Re-surveys were also carried out in order to assess the seasonal changes (Walker & Richardson, 1955) and perennial changes (Walker & Richardson, 1956; 1957 a, b). The perennial changes were found to follow a cyclic pattern (Walker, 1956b) in phase with the cycle of sunspot frequency (Walker, 1956a).

By the use of aerial stereoscopic photography and by application of the ecological laws, which emerged from the analyses of the data obtained from detailed surveying, operated from motor vessels, it was possible to estimate the potential crop of the Laminariaceae growing around Scotland (Walker, 1954 a).

In 1955, it was announced to Parliament that the Institute of Seaweed Research, having completed its original mandate, would in future limit its activities to those of an information centre. In the light of this decision, it was considered a useful piece of work to collect sub-littoral survey data from small but representative areas, easy of access and operation, which would serve as a basis for anyone who might be given the opportunity to continue similar studies at some future date. Five small islands were chosen for this purpose, namely, Ailsa Craig, Holy Island and Inchmarnock in the Firth of Clyde; May Island in the Firth of Forth; Seaford Island in the Outer Hebrides. The sub-littoral surveys around these islands were planned to show differences (if any) in the Laminariaceae crop associated with such factors as sheltered and exposed habitats, incoming and outgoing tidal currents, and depths of sea, for previous surveys had shown that sub-littoral habitats with clear oceanic water supported laminarian growth at greater depths than habitats where the water is enriched with domestic and industrial effluents; the dilution of a marine environment with fresh water from streams and peat bogs is a further factor which may influence the growth of laminariae.

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It has also been shown that the erect plants of *Laminaria cloustoni* Edm. (*L. hyperborea* Foslie) are more likely to be found in habitats where a degree of exposure creates water movements which scour the seabed. e.g., Gruinard Bay, Ross-shire (I.S.R. report No. 186); Fraserburgh, Moray Firth (Walker & Richardson, 1955, 1957 a): on the other hand, the prostrate plants of *Laminaria saccharina* Lamour. will be found attached to stones and boulders partially embedded in the sand and silt which slack water movements permit to accumulate, e.g., North Arran in the Firth of Clyde (Walker & Richardson, 1957 b); Veantrow Bay, North Shapinsay, Orkney (Walker & Richardson, 1956); Loch Ewe, Ross-shire (I.S.R. Report, No. 185); Little Loch Broom (Walker, 1955).

The methods of random sampling of the sub-littoral zone of the above five islands were those used for many years in other parts of Scotland; these methods have been continuously subjected to critical statistical scrutiny (Walker & Richardson, 1957, a, b, c). Generally, a standard error of 5% of the mean fresh weight per unit quadrat was achieved.

The following terminology has been adopted throughout this work:—*Density* is the fresh weight per unit area, weighed to the nearest pound by spring balance immediately the algae were taken on board; *cover* is the degree of colonisation of an area or at a particular depth, and is calculated by expressing the number of quadrats which contained laminariae as a percentage of the total quadrats measured.

Depths of the seabed from which quadrats were taken were recorded to the nearest fathom on board and subsequently standardised to low water mark at ordinary spring tides, based on Admiralty Tide Tables of the appropriate year.

AILSA CRAIG.

Surveys of the Laminariaceae covering extensive areas of the sub-littoral zone of the approaches and estuary of the Firth of Clyde have been carried out during the years 1950 to 1955.

The waters of the approaches to Firth of Clyde move at rates and periods which differ in various localities and account for much of the superficial layers of the sea-bed such as sand which is carried by tidal currents, e.g., around the Mull of Galloway, and deposited where and when the tides slacken and turn; and silt which is brought down by mountain streams and settles when reaching static water. The sea-bed beneath the shallow waters of the Firth of Clyde is generally one of rocks and boulders and usually remains so off land facing a southern exposure and meeting incoming oceanic water, but off land facing a northern exposure and outgoing water accumulations of sand and silt are found.

Ailsa Craig is an isolated columnar rocky islet, rising to 338 metres (1108 feet) situated in the Firth of Clyde, 8 miles from Bennane Head and 10 miles from Girvan, Ayrshire.

A survey of the laminarian crop was carried out during October and November 1955. The sea-bed was sampled between one and nine fathoms (2-17 metres) over areas off the north-east of the island from the lighthouse to the north foghorn, facing the outgoing tidal stream; and over the south-west, from Wee Ailsa to the south foghorn, facing the incoming tidal stream.

The data for the survey are summarised in Tables 1 and 2.

TABLE 1.

AILSA CRAIG NORTH-EAST SUB-AREA: LIGHTHOUSE PIER TO NORTH FOG HORN.

Depth, fathoms, low water mark, ordinary spring tides	1	2	3	4	5	6-9
Mean density (based on all quadrats)						
lb./sq. yard	2·9	1·8	1·8	1·3	0·7	
kg./sq. metre	1·6	1·0	1·0	0·7	0·4	
Seaweed cover, %	100	96	100	68	50	0
Species, per cent of fresh weight						
L. cloustoni	17	4	9	16	—	
L. saccharina	83	96	89	84	100	
Saccorhiza bulbosa	—	—	2	—	—	
L. saccharina						
Weight per plant, g.	70	80	90	100	100	
No. of plants per sq. metre	18·6	11·8	10·2	8·0	8·0	

Of the total of 244 quadrats, 124 contained Laminariaceae; of these 113 contained only *L. saccharina* and of the remainder 9 quadrats contained *L. cloustoni* and *L. saccharina* together at 1, 2, 3, and 4 fathoms, and 2 quadrats contained *L. saccharina* and *Saccorhiza bulbosa* together at 3 fathoms.

TABLE 2.

AILSA CRAIG SOUTH-WEST SUB-AREA: WEE AILSA TO SOUTH FOG HORN.

, fathoms, low er mark, ordinary ng tides	1	2	3	4	5	6	7	8	9
density (based on quadrats)									
./sq. yard	10·9	7·8	5·0	2·3	1·1	0·6	0·2	0·2	
g./sq. metre	5·7	4·2	2·7	1·2	0·6	0·3	0·1	0·1	
ed Cover, %	100	100	100	89	57	38	23	13	0
es, per cent of h weight									
. *cloustoni*	100	100	95	33	22				
. *saccharina*			4	67	67	100	100	100	
accorhiza bulbosa			1		11				
oustoni									
ight per plant, g.	790	640	400						
of plants/sq. etre	7·4	6·4	6·8						
charina									
ight/plant, g.				140	120	150	140	140	
of plants/sq. etre				8·0	7·8	3·6	3·8	4·8	

Of the total of 248 quadrats, 151 contained Laminariaceae; of these, 85 contained only *L. cloustoni* at 1, 2 and 3 fathoms (there was one quadrat at 4 fathoms); and 44 quadrats contained only *L. saccharina*. Of the remainder, 18 quadrats contained *L. cloustoni* and *L. saccharina* together at 3, 4 and 5 fathoms and 3 quadrats contained *L. cloustoni* and *Saccorhiza bulbosa* together at 3 and 5 fathoms.

The survey showed that the Laminariaceae did not grow below 5 fathoms off the north-east nor below 8 fathoms off the south-west of Ailsa Craig.

Laminaria saccharina was strongly dominant over the north-east area at all depths where laminariae were found, namely, 1 to 5 fathoms, while over the south-west area, *Laminaria cloustoni* was almost a pure stand at 1, 2 and 3 fathoms but from 4 to 8 fathoms, *L. saccharina* gained supremacy.

The number of *L. saccharina* plants per unit area decreased with increasing depth over both areas. The mean weight of *L. saccharina* plants increased with increasing depth over the north-east—this is unusual—but a fair uniformity of plant weight at all depths was found over the south-west area.

At 4 and 5 fathoms, where the data for the two areas in respect of *L. saccharina* overlap, the number of plants per unit area was the same but the plants were heavier from the south-west. The species of *L. saccharina* over the north-east area grew considerably nearer the surface of the sea than over the south-west, yet its growth was poorer. The mean density of the Laminariaceae over the south-west, *based only on those quadrats which contained these algae,* follows a logarithmic regression with increasing depth. This might be expected, as the co-efficient of extinction of light by clear seawater is also logarithmic; on the other hand, the density of the algae over the north-east showed no such regression.

The distribution of the Laminariaceae of Ailsa Craig conforms to an ecological pattern which other and more extensive areas of the sub-littoral zone of the Firth of Clyde have presented.

HOLY ISLAND.

Holy Island is situated on the east of the Isle of Arran; it stands off Lamlash, providing this town with shelter and giving quiet anchorage to Lamlash Bay. The island is 312 metres (1025 feet) high. The island is subjected to a marine environment similar to that around Ailsa Craig. Part of the incoming and outgoing tidal stream through the Firth of Clyde passes between Holy Island and Isle of Arran at a rate of 1·5 knots.

The survey was carried out during November and December 1955, between one and nine fathoms (2-17 metres) off the north of the island within the kilometre lines of the national grid 204-7, 631-2, and off the south within kilometre lines 206-8, 627-9.

The survey data are summarised in Tables 3 and 4.

The survey showed that Laminariaceae failed to grow below 8 fathoms (15 m.) off both the north and south of Holy Island. *Laminaria saccharina* was almost a pure stand over the northern area from 1 to 8 fathoms. Over the southern area, *Laminaria cloustoni* was dominant at 1 and 2 fathoms, shared equally with *L. saccharina* at 3 and 4 fathoms but from 5 to 8 fathoms *L. saccharina* was the only species of Laminariaceae found.

The number of plants per unit area of *Laminaria saccharina* decreased with increasing depth over both the northern and southern habitats. The mean weight of individual plants showed no trend; groups of very young plants were found in some quadrats, but many of these young plants do not survive the

TABLE 3.

HOLY ISLAND NORTH SUB-AREA.

., fathoms, low er mark, ordinary ng tides	1	2	3	4	5	6	7	8	9
density (based on uadrats)									
../sq. yard	4·2	3·5	2·5	1·4	1·1	0·9	0·5	0·3	
g./sq. metre	2·3	1·9	1·4	0·8	0·6	0·5	0·3	0·2	
ed Cover,	91	85	83	63	43	43	43	25	0
-s, per cent of h weight									
aminaria cloustoni	—	—	—	—	—	4	—	14	
. saccharina	100	100	95	100	100	96	100	86	
accorhiza bulbosa	—	—	5	—	—	—	—	—	
aria saccharina									
ght per plant. g.	110	140	100	100	190	140	150	150	
of plants per sq. etre	22·0	16·4	15·8	12·0	7·1	8·2	4·4	3·5	

TABLE 4.

HOLY ISLAND SOUTH SUB-AREA.

., fathoms, low er mark, ordinary ng tides	1	2	3	4	5	6	7	8	9
density (based on uadrats)									
../sq. yard	4·5	3·8	1·9	1·3	0·9	0·8	0·8	0·2	
g./sq. metre	2·4	2·1	1·0	0·7	0·5	0·4	0·4	0·1	
ed Cover, %	97	97	81	76	52	48	52	15	0
ss, per cent of n weight									
aminaria cloustoni	66	65	41	12	—	—	—	—	
digitata	12	—	—	—	—	—	—	—	
saccharina	22	35	59	88	100	100	100	100	
aria cloustoni									
ght per plant, g.	270	420	130	150					
of plants per sq. etre	9·4	7·1	10·8	7·1					
aria saccharina									
ght per plant, g.	90	60	70	90	100	80	130	150	
of plants per sq. etre	18·8	22·0	14·4	9·9	9·3	11·1	6·4	3·5	

winter storms (Walker & Richardson, 1957 b). From the northern habitat, the plants of *L. saccharina* had a greater mean weight at all depths than those from the south; on the other hand, the number of plants per unit area from 5 to 8 fathoms, where this species had no competition, was less in the north.

In spite of the above differences in plant and species distribution, the density (master mean) from 1 to 8 fathoms, was the same for the north and south sub-littoral areas. It would appear that conditions for growth are the same off the north and south of the island; nevertheless, the nature of the seabed in the shallow water of the south permits the establishment of *Laminaria cloustoni,* while no such advantage for this species occurs off the north of the island.

Holy Island presents an ecological pattern similar in some respects to that of Ailsa Craig, namely, southern exposures allow *Laminaria cloustoni* to dominate the shallow waters but to give place to *Laminaria saccharina* in deeper water. The southern areas of both islands support Laminariaceae to the same depth. The outstanding difference was found between the northern habitats of the two islands; Holy Island supported Laminariaceae with greater density and at greater depths.

INCHMARNOCK.

Inchmarnock is a small island off the west coast of the island of Bute, situated in the upper reaches of the Firth of Clyde. A survey of the Laminariaceae, from low water mark down to ten fathoms (18·5 metres) was carried out during January and February 1956. For the purposes of the survey, the sub-littoral zone was divided into sub-areas as follows:—

North	…… Between Kilometre grid lines	661-2	201-3
South	…… Between Kilometre grid lines	657-9	201-3
East	…… Between Kilometre grid lines	659-61	202-3
West	…… Between Kilometre grid lines	659-61	200-2

The data from the survey are summarised in Tables 5-9.

Considered as a whole, the North sub-area, from which 164 quadrats were measured (Table 5), supported a seaweed cover of 62% and a mean density (based on the fresh weight of Laminariaceae in the quadrats containing the plants) of 2·0 lb./sq. yard. *Laminaria saccharina* was found to be almost a pure stand, although small quantities of *Laminaria cloustoni* were found at

TABLE 5.

INCHMARNOCK NORTH SUB-AREA.

n, fathoms low er mark, ordinary ing tides	1	2	3	4	5	6	7	8	9
density (based on quadrats)									
o./sq. yard	2·0	1·3	1·1	0·9	0·8	1·5	1·1	1·5	0·9
g./sq. metre	1·1	0·7	0·6	0·5	0·4	0·8	0·6	0·8	0·5
eed Cover, %	87	69	62	47	56	69	47	65	40
naria saccharina									
mber of plants/sq. netre	7·0	7·3	7·7	8·2	4·5	6·5	10·2	10·2	8·2
ight/plant, g.	150	140	120	120	160	170	120	110	150

TABLE 6.

INCHMARNOCK SOUTH SUB-AREA.

n, fathoms low er mark, ordinary ing tides	1	2	3	4	5	6	7	8	9
density (based on quadrats)									
o./sq. yard	1·1	2·2	1·2	1·5	1·6	1·3	1·2	1·4	0·8
g./sq. metre	0·6	1·2	0·6	0·8	0·9	0·7	0·6	0·8	0·4
eed Cover, %	59	48	58	66	58	59	63	55	44
naria saccharina									
mber of plants/sq. netre	6·6	27·3	9·5	13·6	14·1	11·8	9·6	13·6	10·6
ight/plant, g.	150	90	110	90	100	100	100	100	100

TABLE 7.

INCHMARNOCK EAST SUB-AREA.

n, fathoms low er mark, ordinary ing tides	1	2	3	4	5	6	7	8	9
density (based on quadrats)									
o./sq. yard	1·3	0·9	0·4	0·4	0·4	0·3	0·3	0·4	0·6
g./sq. metre	0·7	0·5	0·2	0·2	0·2	0·2	0·2	0·2	0·3
eed Cover, %	60	56	32	37	35	33	31	25	37
naria saccharina									
mber of plants/sq. netre	8·3	7·3	5·5	7·0	7·0	5·5	3·3	6·4	3·9
ight/plant, g.	140	120	110	90	90	100	160	120	230

one and two fathoms in the north-west of the sub-area. The mean weight of all plants of *Laminaria saccharina* was 147 g. The number of plants averaged 7·8 per square metre in those quadrats which contained them. A study of Table 5 indicates that the loss of density with increasing depth was due chiefly to decreases in the seaweed cover, plant numbers and their weights being relatively more constant.

The South sub-area, from which 301 quadrats were measured (Table 6), supported a seaweed cover of 57% and a mean density (based on the fresh weight of Laminariaceae in the quadrats containing these plants) of 2·4 lb./sq. yard. *Laminaria saccharina* was found to be almost a pure stand although small quantities of *Laminaria cloustoni* were found at one fathom in the south-east and at two fathoms in the south-west of the sub-area. The mean weight of all plants of *Laminaria saccharina* was 100 g. The number of plants averaged 12·7 per square metre. The differences in density at various depths will be seen from Table 6 to be due chiefly to plant numbers, for the mean weight of plants and the seaweed cover were found to be relatively more constant.

The comparatively high seaweed density at two fathoms was caused by the grouping of large numbers of plants in 5 quadrats, exclusion of which from the data gives the number of plants as 10·6/sq. metre and the density as 0·8 kg./square metre—almost that found at other depths.

The East sub-area, from which 168 quadrats were measured (Table 7), supported a seaweed cover of 41% and a mean density (based on the fresh weights of Laminariaceae in the quadrats containing these plants) of 1·5 lb./square yard. *Laminaria saccharina* was found to be a pure stand in the sub-area. The mean weight of all plants of *Laminaria saccharina* was 124 g. The number of these plants averaged 6·5 per square metre. The difference in the density of seaweed at various depths was due to a combination of variables associated with plant numbers and their weights and also the seaweed cover.

The West sub-area, from which 215 quadrats were measured (Table 8), supported a seaweed cover of 38% and a mean density (based on the fresh weight of Laminariaceae in the quadrats containing these plants) of 1·6 lb./square yard. *Laminaria saccharina* was found to be a pure stand in the sub-area. The mean weight of all plants of *Laminaria saccharina* was 116 g. and the number of plants averaged 7·4/square metre. The large difference in

TABLE 8.

INCHMARNOCK WEST SUB-AREA.

, fathoms low er mark, ordinary ng tides	1	2	3	4	5	6	7	8	9
density (based on quadrats)									
./sq. yard	0·8	1·2	0·7	1·4	0·5	0·2	0·5	0·2	0·1
g./sq. metre	0·4	0·6	0·4	0·8	0·3	0·1	0·3	0·1	0·1
ed cover, %	61	64	46	65	30	17	39	11	12
aria saccharina nber of plants/sq. etre	6·2	7·9	4·9	8·5	6·0	3·6	5·4	4·0	2·7
ght/plant, g.	100	110	140	120	130	130	110	170	170

TABLE 9.

INCHMARNOCK.

	Sub-area			
	North	South	East	West
ean density of Laminariaceae (based on quadrats with these species) g./sq. metre	1·1	1·3	0·8	0·9
ver, %	62	57	41	38
oduct of 1 and 2 equals mean density based on all quadrats	0·68	0·74	0·33	0·34
ean No. of plants/sq. metre	7·8	12·7	6·5	7·4
ean weight of plant, g.	147	100	124	116

seaweed density at various depths was caused more by the seaweed cover than by plant numbers or their weight, although these two factors contributed in some degree.

The foregoing analyses showed that *Laminaria saccharina* was the dominant species during the winter of 1955 around Inchmarnock and had colonised to the same depth (9 fathoms) around the whole island. The results of the survey of the 4 sub-areas are summarised in Table 9. The results show that the crops of the north and the south sub-areas were alike, likewise those of the east and the west, but the differences between north-south and east-west were significant.

Inchmarnock is subjected to tidal currents of less force than is Ailsa Craig, and also to less differences between the incoming and outgoing waters. The areas which meet the tidal currents support a greater algal crop than the areas where the currents pass parallel to the shore. The laminariae around Inchmarnock grew with less density than those of Ailsa Craig and Holy Island.

MAY ISLAND.

The Estuary of the Firth of Forth is approached between Fife Ness and Gin Head, 13·5 miles apart. May Island lies approximately midway between these points. On the western side of the island the cliffs rise to 200 feet (60 metres) and the land slopes down to the east and the exposure of the North Sea. The cliffs are steep-to on the west while sunken rocks occur on the east. Several deep fissures indent the coast of the island.

The sub-littoral zone around the island was surveyed during April-May 1956, when 580 quadrats were measured from low water mark down to ten fathoms (18·5 metres). Of the total quadrats, 52% contained some Laminariaceae. The area was divided into four sub-areas for the purpose of comparing the growth of laminarian crop in sheltered and exposed habitats, and the data for these sub-areas are summarised in Tables 10-13.

North-east sub-area (North Ness to East Tarbet). In this sub-area (Table 10) the density and cover decreased with increasing depth. The average number of plants per unit area similarly decreased. The average weight of the plants of *Laminaria cloustoni* (the only species of Laminariaceae found in this sub-area) showed no trend with depth.

North-west sub-area (The Pool to Alterstones). In this sub-area (Table 11) the decrease in density with increasing depth was pronounced so that the greater part of the crop was found between low water and two fathoms, whereas over the north-east a similar range occurred from low water to six fathoms.

The species *Laminaria cloustoni* and *Laminaria saccharina* were growing in very close proximity at low water and one fathom, for most of the quadrats contained both; at two fathoms, while both species were found, they were in separate quadrats. From three to ten fathoms *Laminaria saccharina* alone was found, but the plants were few in number.

TABLE 10.

MAY ISLAND NORTH-EAST SUB-AREA.

Depth, fathoms low water mark, ordinary spring tides	0	1	2	3	4	5	6	7	8	9	10
Mean density (based on all quadrats)											
lb./sq. yard	9·8	10·4	5·2	4·5	3·3	1·3	1·4	0·5	0·4	0·1	0·1
kg./sq. metre	5·3	5·6	2·8	2·4	1·7	0·7	0·8	0·3	0·2	0·1	0·1
Seaweed cover, %	100	100	93	82	82	54	75	40	30	11	10
Laminaria cloustoni											
Number of plants/sq. metre	19·0	13·6	10·3	8·1	6·6	5·5	5·5	3·5	3·9	2·3	4·7
Weight of plant, g.	280	410	290	360	320	230	160	190	180	230	110

TABLE 11.

MAY ISLAND NORTH-WEST SUB-AREA: THE POOL TO ALTERSTONES.

Depth, fathoms low water mark, ordinary spring tides	0	1	2	3	4	5	6	7	8	9	10
Mean density (based on all quadrats)											
lb./sq. yard	13·2	6·5	1·3	0·6	0·2	0	0·4	0·1	0·1	0	0·1
kg./sq. metre	7·1	3·5	0·7	0·3	0·1	0	0·2	0·1	0·1	0	0·1
Seaweed cover, %	100	80	58	50	22	0	44	11	8	0	10
Species, per cent of fresh weight,											
Laminaria cloustoni	97	57	46	—	—	—	—	—	—	—	—
Laminaria saccharina	3	43	54	100	100	—	100	100	100	—	100

South-east sub-area (The Middens to South Ness). In this sub-area (Table 12), while the seaweed cover was high, the density was relatively low. The dominant species was *Laminaria cloustoni*; *Laminaria saccharina* was found at some depths.

South-west sub-area (Mill Door to Maiden Hair). In this sub-area (Table 13) *Laminaria cloustoni* was found to be the dominant species from low water to four fathoms, below which depth it was not found; below five fathoms *Laminaria saccharina* also disappeared.

Comparison of the laminarian crop growing at this time of the year (April-May) on the north-east and north-west of May Island shows the following significant differences:—

(0-10 fathoms, master mean)	density (kg./sq.m.)	cover (%)
north-east	0·45	62
north-west	0·11	34

The more exposed north-east supports a much denser growth of Laminariaceae than does the sheltered north-west of the island.

Similar comparisons are not possible with the south-east and south-west, for the Laminariaceae were not found at depths greater than four fathoms in the south-west and it was not possible to sample in the shallow water of the south-east, owing to swell and inshore rocks. Only at two depths, namely three and four fathoms, can comparisons be made and there it is found that density and cover were greater in the south-east than in the south-west. The eastern side of the island, therefore, subjected to the exposure of the North Sea and the consequent scouring of the sea-bed and aeration of the sea, is a more suitable environment for laminarian vegetation than the western side where sheltered conditions prevail. The silt brought down from the upper reaches of the River Forth accumulates on the sea-bed adjacent to the western side of the island and so covers the stable substrata of rocks and boulders essential for the growth of the upright mature plants of *Laminaria cloustoni*. The prostrate plants of *Laminaria saccharina* grow on less rigid substrata such as stones but even this species cannot grow on mud which covers the greater part of the River Forth and its estuary.

The sub-littoral zone facing the incoming waters supports greater quantities of Laminariaceae at greater depths than the zone facing the outgoing waters. This was found at Ailsa Craig in the Firth of Clyde, similarly isolated as May Island in the Firth of Forth.

TABLE 12.

MAY ISLAND SOUTH-EAST SUB-AREA: THE MIDDENS TO SOUTH NESS.

fathoms, low r mark, ordinary ng tides	0-2	3	4	5	6	7	8	9	10
density (based on uadrats)									
/sq. yard	*	2·3	3·3	2·3	4·2	1·9	0·6	0·2	
./sq. metre		1·2	1·8	1·2	2·3	1·0	0·3	0·1	
ed Cover, %	*	91	100	71	85	80	45	24	0
s. per cent of weight									
minaria cloustoni		67	95	100	100	90	75	67	
saccharina		33	5	—	—	10	25	33	
aria cloustoni									
ber of plants sq. etre		9·9	8·4	7·0	6·2	5·1	3·9	2·3	
ght of plant, g.		170	260	240	420	290	200	300	

*No quadrats were obtained from these depths owing to heavy swell reaking on inshore reefs.

TABLE 13.

MAY ISLAND SOUTH-WEST SUB-AREA: MILL DOOR TO MAIDEN HAIR.

Depth, fathoms, low water mark, ordinary spring tides	0	1	2	3	4	5	6-10
Mean density (based on all quadrats)							
lb./sq. yard	5·2	6·6	1·8	1·1	1·2	0·3	
kg./sq. metre	2·8	3·6	1·0	0·6	0·7	0·2	
Seaweed Cover, %	85	95	42	26	47	32	0
Species, per cent of fresh weight							
Laminaria cloustoni	98	96	68	91	74	—	
L. saccharina	2	4	32	9	26	100	
Laminaria cloustoni							
Number of plants sq. metre	8·5	9·5	6·4	6·5	6·1		
Weight of plant, g.	430	380	310	400	300		

SEAFORTH ISLAND

A sub-littoral survey of the Laminariaceae was carried out during March 1956 in two localities of Loch Seaforth, Outer Hebrides; (a) the channel between the south-east of Seaforth Island and Lewis (kilometre grid 121-122, 909-911) and (b) the channel between the north-west of Seaforth Island and Harris (kilometre grid 119-121, 911-913).

The south-east channel faces the incoming tidal stream from the Minch while the north-west channel receives the outgoing drainage waters from the extensive upper Loch Seaforth. The south-east channel reaches considerable depths, but the bed of the north-west channel rarely drops to 6 fathoms (11 metres), low water mark at ordinary spring tides. Seaforth Island on the south-east is steep and the littoral zone narrow, but on the north-west it slopes gradually to the sea, giving a wide zone over which a very dense cover of Fucaceae flourishes. From the south-east sub-area 200 quadrats were measured and from the north-west 250 quadrats.

In both sub-areas the Laminariaceae did not grow below 5 fathoms and from low water to 5 fathoms (9 metres) a pure stand of *Laminaria digitata* was found. This species possessed a lamina wider in relation to its length compared with the plants growing in other areas of Scotland. This species shows considerable variation with habitat (Walker 1954 c).

The data for the survey are summarised in table 14.

It will be seen that a progressive decrease in density with increasing depth took place in the south-east sub-area; this did not occur in the north-west. Cover also decreased with increasing depth but in the north-west the rate was more pronounced. The plant weight was greatest at two fathoms in both sub-areas. Plant numbers progressively decreased with increasing depth in the south-east and would have done so in the north-west but for unusually large numbers of plants grouped together in five of the quadrats.

At one fathom, where the cover was the same for both sub-areas, the density in the south-east was higher, owing to heavier plants. At two fathoms, where the density was the same for both sub-areas, the cover was greater and the plants were heavier in the south-east, but these factors were partially offset by fewer plants.

TABLE 14.

SEAFORTH ISLAND.

Depth, fathoms, low water mark, ordinary spring tides	Mean Density (based on all quadrats) (lb./sq. yard (×0·54 for kg./sq. metre)		Seaweed Cover (%)		Plants			
					Mean fresh weight of plant lb. (g.)		Number of plants per sq. yard	
	S.E.	N.W.	S.E.	N.W.	S.E.	N.W.	S.E.	N.W.
0	6·9	3·8	86	76	·48 (260)	·41 (220)	17·2	11·9
1	4·7	3·9	84	84	·44 (240)	·34 (180)	12·6	13·6
2	3·6	3·6	77	50	·56 (300)	·48 (260)	8·4	14·9
3	1·7	0·7	69	32	·42 (230)	·34 (180)	6·0	6·1
4	0·7	0·1	37	9	·50 (270)	·31 (170)	3·7	5·3
5	0·5	0	36	3	·39 (210)	·50 (270)	3·8	2·0
Sub-area as a whole 0-5 fathoms	3·0	2·0	67	42	·46 (250)	·40 (220)	9·4	11·8

When both sub-areas are compared *in toto*, the product of the plant weight and number shows little difference; the factor responsible for the difference in density is the degree of colonisation; this is greater in the south-east channel scoured by incoming oceanic water. The silt, brought down from the upper reaches of Loch Seaforth, settles more in the shallow north-west channel forming an unstable substrate on which mature plants of Laminariaceae cannot obtain attachment.

The reason for the absence of any Laminariaceae below 5 fathoms in the south-east channel is unknown.

SUMMARY.

During the period October 1955 to March 1956 sub-littoral surveys were completed of the Laminariaceae around five widely separated islands of Scotland, namely, Ailsa Craig; Holy Island; Inchmarnoch, Firth of Clyde; May Island, Firth of Forth; and Seaford Island, Loch Seaford, Outer Hebrides. The sub-littoral areas of the islands were selected to show the differences in species and growth in relation to tidal streams.

It was found that the growth of Laminariaceae was denser in the areas exposed to the incoming tidal currents than in those exposed to the outgoing tidal currents. Growth decreased with increased depth.

Around Inchmarnoch, *Laminaria saccharina* was almost a pure growth and around Seaford Island *Laminaria digitata* was a pure growth. Around Ailsa Craig, Holy Island and May Island, *Laminaria cloustoni* was in greater evidence in areas facing the incoming tide, while *Laminaria saccharina* colonised more the areas facing the outgoing tide.

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ISLAND VEGETATION OF SOME WEST HIGHLAND FRESH-WATER LOCHS.

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INTRODUCTION.

The destruction of the Scottish forests by fire, axe and grazing animal is an old story now and surviving fragments of native or quasi-native woodland, though self-sown, are known to be anything but natural in either structure or floristics. While seeking out and studying the best of these fragments in the summer of 1953 and 1954 it occurred to me that wooded and scrub covered islands in the west and north-west Highlands might have something of importance to contribute to the understanding of natural forest dynamics.

While it had eventually to be concluded that few if any of the islands had escaped modification of one kind or another, the notes that were made seemed to be of some general interest, especially as many of the islands were due for submergence by the rising waters of hydro-electric development.

Very small islands become partly or wholly inundated in winter storms and are thus maintained in a pioneer phase of woodland succession. The larger islands have invited exploitation as a source of timber, summer grazing or even for permanent settlement. Many of intermediate size have passed through this phase to be abandoned later and recolonised by woodland. The one-inch maps of the Ordnance Survey, fully revised between 1920 and 1930, do not always show these islands as they are to-day; the change may have been from wooded to unwooded or *vice versa*. Even the smallest islands are not necessarily immune to fire, especially where they carry heather, juniper and pine.

LOCHAN NA H-ACHLAISE, BLACKMOUNT.

There are numerous small islands in this loch, all composed of unsorted glacial material. At the present day they are undergoing colonisation by birch, willow and rowan, though there are few seed sources in the neighbourhood. The common juniper occurs on most of the islands, although it is no longer to be found elsewhere in the district.

The largest island is of considerable interest. It is about half an acre in area and rises 8-10 ft. above normal water level. There are several dead pines (2 ft. diam. breast height and at least 200 years old) with pioneer crowns and one that still retains a few live branches. Numerous young pines vary from 10 to 70 years of age and are up to 9 inches in diameter.

The remaining tree layer consists of several 30-ft. tall birches and there is an abundant low scrub of birch (*Betula pubescens*), rowan (*Sorbus aucuparia*), willow (*Salix* spp.) and juniper (*Juniperus communis*) of both growth forms. The field layer has knee-high *Vaccinium myrtillus* and *Calluna vulgaris* with stem bases buried deeply in *Sphagnum* and hypnaceous mosses. The heather is a mosaic of growth of different ages and the moribund patches are festooned with lichens. Rowan saplings are numerous but they are trimmed by deer shortly after they attain the height of the dwarf shrubs.

Soil is a variable depth of mor humus over boulders or coarse, leached sand and gravel.

LOCH LAIDON, MOOR OF RANNOCH.

Eilean Iubhair was the only island considered large enough to merit detailed examination. This is again an aggregation of glacial boulders (about 1 acre in extent) but there has been a greater accumulation of sands and gravels around these than in the smaller Lochan na h-Achlaise where wave action is bound to be less effective.

The woodland cover is predominantly birch with an understorey of willow, rowan and bird cherry (*Prunus padus*). There are no traces of pine, even as stumps, and no yew trees (*Taxus baccata*) in spite of the name of the island. The birches do not form an even-aged stand and without ring counts it is impossible to decide the amount of age diversity that exists. The largest trees, occupying the centre of the island, are mostly wind-thrown but are still alive.

The field layer is dominated by tall *Vaccinium myrtillus* in the bouldery parts of the island with many 18-inch rowan saplings bitten back by deer. The sand and gravel areas are occupied by a grassy vegetation with abundant forbs, the soil consisting of up to 9 inches of dark mull humus over 2-3 inches of leached granite sand and a considerable depth of reddish-brown sand with lines of humus enrichment in the upper layers.

Another small island nearby was covered with 5-ft. tall juniper scrub with occasional birch standards while yet another carried a dense thicket of young birch and rowan 15-ft. tall and with the stems only 12-18 inches apart in places.

FIONN LOCH, FISHERFIELD FOREST.

West Island.—Like the other islands so far described, this consists of an accumulation of boulders (gneiss), with added deposits of sand and gravel, measuring approximately 100 × 50 yards. At one end of the island there is a group of pines of uniform age (about 60 years) regularly spaced and growing among large mossy boulders along with tall heather, crowberry and blaeberry. Among the pines there is a group of four junipers but there are no pine seedlings, although cones are being produced by the trees.

The remainder of the island is occupied by birch wood with some holly and rowan and with marginal alder and ash. The birches and hollies have been coppiced at some time since they consist entirely of thick stools with many poles. The woodland floor is dominated by *Luzula sylvatica* with straggling honeysuckle (*Lonicera periclymenum*) and clumps of *Blechnum spicant* and *Dryopteris spinulosa.* Rowan and holly (*Ilex aquifolium*) seedlings are abundant but their development is checked by browsing deer. Birch seedlings and saplings are only to be found on the shore.

The outer trees of the island are badly wind-cut because of the absence of any shelter on the mainland and the absence of high ground to the south and west.

South Island.—This is a round bedrock island of some 50 yards diameter entirely covered by a dense stand of large and ancient hollies fifteen to twenty feet high. Mature birches and ashes fringe the shore, the ashes forming the most obvious seed source for younger shore-line trees on the west island and the adjacent mainland.

The floor of the wood is carpeted with *Luzula sylvatica, Dryopteris spinulosa, Oxalis acetosella* and *Endymion nonscriptus,* growing in deep reddish-brown humus.

There are twelve heron nests in the trees with the usual thick nitrogenous top dressing below them. This is probably the heronry mentioned by St. John (1849).

Eilean Fraoch.—This is the largest island of the group and rises 30-40 ft. above water level. It is shown as wooded on the 1-inch O.S. map. It consists of boulders, possibly piled on a core of solid rock, and is covered with long heather and crowberry (*Empetrum* spp.) in a thick carpet of *Sphagnum* and hypnaceous mosses. Bushes of alder (*Alnus glutinosa*), birch and rowan, five or six feet high, are scattered here and there, some of them having obviously developed as coppice shoots.

A number of small islands close to the boathouse are burned from time to time so that they provide a complete contrast to those described above in carrying only a poor crop of uniformly aged heather with a few straggling birches along the shore.

LOCH SIONASCAIG, INVERPOLLY FOREST.

Eilean Mor.—This is a large rock island of about 50 acres, comprising several low hills which reach about 50 ft. above water level. The woodland is mainly of tall birch with a floristically poor and grassy floor but there is also a small area of pure rowan wood where the trees are 20-30 ft. tall. Deer grazing seems to be particularly heavy on this island and the numerous holly saplings have been trimmed into little rounded bushes 2-3 ft. in height.

Small north island.—This island is completely covered with low (12-15 ft.) multiple-stemmed birch with subordinate rowan and willow. Holly is present as 2-ft. bushes as on Eilean Mor. The woodland floor is a smooth carpet of hypnaceous mosses with scattered grasses and blaeberry, but there are also large areas of denser canopy where the *Hylocomium, Thuidium* and *Rhytidiadelphus* are replaced by *Dicranum majus* and *Leucobryum glaucum* with scattered *Luzula pilosa.* The absence of grazing disturbance in the dense shade is indicated by the occurrence of normally corticolous lichens, such as *Lobaria pulmonaria,* on the woodland floor. Rowan seedlings are numerous but there is no complete regeneration of any tree species.

LOCH BEANNACH, ASSYNT.

The main island of the south-east group consists of bedrock and carries 20-30 ft. high rowan-birch wood with a shore fringe of alder. There is only one tree of oak (*Quercus petraea*) but there are extensive areas of brown soil which bear a flora more closely resembling oakwood than Highland birchwood: *Holus mollis* and *Pteridium* with *Endymion, Melandrium dioicum, Rumex acetosa, Corydalis claviculata, Geranium robertianum* and *Angelica sylvestris.* Other parts of the island are heathy with *Vaccinium, Calluna, Teucrium, Ptilium crista-castrensis* and *Sphagnum* and carrying smaller, contorted birch.

The small outlying islands of the group consist of tumbled boulders and these, like the boulder islands of the west central Highlands, are covered with long heather and blaeberry and scrub birch.

LOCH MORAR.

Eilean a'Phidhir.—This is probably the largest island in the group with an area of more than 50 acres and reaching a height of 129 ft. It is basically a rock island with extensions of boulders and fluvio-glacial debris.

It is almost entirely covered by a dense stand of tall, straight pine. The trees on the steep north-west facing slope are stunted and wind cut and must formerly have grown in open stand among tall *Calluna* but this has recently been burned and many trees have been killed. The wind has then gained entrance to the wood and felled many of the hitherto protected trees on the summit and on the east slope.

Round the bay on the north-east corner of the island the pines are mixed with other species such as *Tilia vulgaris, Acer pseudoplatanus* and *Taxus baccata* which are probably self-sown. The *Taxus* is regenerating successfully here but the seedlings of the hardwoods do not develop. The *Taxus* bushes are badly wind-cut where at all exposed to the north and west. There is a well-developed brown soil in this part of the woodland in contrast to the podsol under the pure pine, and traces of old walls indicate that this better soil is probably due to past human influence.

The pure pine wood at the north end of the island consists of scattered pioneers with their 40-80 year old progeny. Thin birches and rowans run up to mingle in the pine canopy and bushes of birch, willow, rowan and yew form an understorey.

The woodland floor of this area has abundant *Oxalis acetosella* with some *Listera cordata, Blechnum* and *Calluna* growing in a carpet of hypnaceous mosses and shed needles. There are also ocal patches dominated by *Luzula sylvatica, Deschampsia flexuosa* and *Polytrichum formosum.* Much of the pine is in the ate thicket stage of development in which the ground is completely covered with a layer of fallen needles and encumbered with dead branches.

Towards the south end of the island the floor of the wood s strewn with boulders overgrown with hypnaceous mosses and *Sphagnum* and with a few shoots of *Goodyera repens.* There are small clearings with stunted pines of head height, apparently the same age as the rest of the wood, growing in tall heather and deep *Sphagnum.*

Apart from the brown earth area the soil consists of several nches of mor humus over 4-5 inches of leached grey sand. This may lie directly on rock in the higher parts of the island but is usually separated from it by a shallow B horizon. Charcoal fragments were often encountered at the base of the Ao layer as n mainland woods.

Dear tracks and wallows were found all over the island and browsed seedlings of holly and rowan were abundant.

Eilean nam Breac.—This is separated from Eilean à Phidhir by a fordable channel. Pioneer pines are again surrounded by a dense stand of younger trees showing good sequences in the disappearance of *Calluna, Vaccinium* and mosses as the canopy thickens up. In the better lighted areas oak and alder occur as undershrubs, while in the densest shade there are neither vascular plants nor cryptogams and the ground is littered with branches and fallen trees.

The remaining islands were not visited since the presence on them of *Rhododendron* and Douglas Fir indicated a greater amount of human interference.

LOCH AN EOIN, BEINN DAMPH FOREST.

The largest island in this loch, which lies at 1,150 ft. has been chosen as an example of the many juniper-covered islands of the north-west. The spreading bushes of juniper (1 ft. tall and with stems up to 3 inches diameter) form extensive patches in a cover of uneven-aged heather which is buried deep in *Rhacomitrium lanuginosum,* hypnaceous mosses and *Sphagnum.* A few wind-cut and browsed trees of birch and rowan up to 10 ft. tall occur especially round the shore. The contrast which the island affords with the adjacent mainland can best be summarised as follows:

ISLAND.	MAINLAND.
Abundant juniper, heather.	Only dead juniper stems, sparse heather.
Abundant *Empetrum hermaphroditum*.	Little *Empetrum*.
Little *Molinia*, *Trichophorum*.	Abundant *Molinia*, *Trichophorum*.
Sphagnum fuscum present.	No *Sphagnum fuscum*.
No charcoal under peat.	Occasional charcoal under peat.
All peat fibrous. Mull humus under juniper.	Mainly pseudo-fibrous scirpus-molinia peat.
Little bare peat and no erosion pavement.	Much bare peat and erosion pavement.
Abundant grouse droppings.	Few scattered grouse droppings.
A few stunted trees.	No trees.

DISCUSSION.

The woodland history of islands such as those described above may sometimes be guessed with a fair degree of certainty. Thus, there is little doubt that the larger islets in Lochan na h-Achlaise and the neighbouring Loch Ba at one time carried fragments of the great Rannoch pine forest and that the surviving trees are genuine relics of that time comparable to those not far away in Glen Etive and by Loch Tulla. The islands have not entirely escaped interference so that the pines have persisted on the one island only, and even here there is a distinct break in continuity of regeneration between the early 18th and early 20th centuries, possibly caused by burning. The present vegetation shows that the large island has escaped extensive burning for at least seventy years.

It is also probable that the smaller islands of Loch Laidon were at one time occupied by pine but that the larger Eilean Iubhair always carried a high proportion of birch and other deciduous trees on its deeper and more fertile soil where water-borne sands and silts have accumulated. It is also conceivable that one or more yews were also present within historical times. Human interference has probably been slight within the last 100 years.

The situation on the Fionn Loch islands must have been essentially the same as on Eilean Iubhair and it seems likely that, although the rock is uniform throughout, acid peat formation and pine colonisation took place on the boulders and coarser glacial material while a brown soil developed, with birch olonisation, on the finer fractions. The same influences have een at work in determining the distribution of oak and pine on he north side of Loch Maree, the oak occupying the richer lluvial and colluvial soils by stream sides, in hollows and along he lower slopes while pines are found wherever peat has eveloped directly on the unweathered gneisses (mainly basic rthogneisses) of the upper crags and rock buttresses descending o the loch.

The rock islands of Loch Sionnascaig and Loch Beannach ave developed predominantly brown soil, and carry birch and ixed woodland, possibly because of the higher base status of he rock and the accumulation of weathering products. These ontrast with the rock islands of Loch Morar where podsolisation nd mor formation have taken place. Webb (1947) has pointed ut that where acid peat accumulation has occurred on the imestone of Carrowkeel in Ireland it has usually been direct on he rock and not over a limestone soil. This is true for many f the Highland limestones and the same principle can often be pplied to less basic rock as well.

Birch woodland can of course be found on both acid peat and rown earth soils and it may well be seral to pine on the one and o oak on the other. In the absence of pine and oak seeds to ontinue the succession the further course of events is not clear. app (1953) has introduced the concept of non-continuous tree over throughout upland Britain and applied it to oak and pine s well as to birch. The evidence in favour of a birch/non wood- and cyclo-climax in the presence of grazing animals is certainly trong.

The situation on small islands can therefore be summarised s follows:—

ock islands—Basic gneisses → Brown earth → Oak, birch, etc.
Siliceous gneisses → Podsol or deep peat → Pine.
oulder islands—Coarse material → Peat and mor humus → Pine.
granites and Fine material → Brown earth → Oak, birch.
neisses)

The absence of tree cover from the Loch an Eoin island, which as obviously escaped fire and much of the deer browsing, can nly be ascribed to exposure. Even the prostrate juniper mats re scorched in exposed places while they are bright green in the hollows. The vegetation probably bears a fairly close resemblance to the natural vegetation cover at this altitude and represents the transition from forest to the subalpine zone of dwarf shrub communities (Poore and McVean, 1957). It can be supposed that birch and rowan scrub, with perhaps some pine, would be more abundant given a little shelter from scrub woodland on the adjacent mainland.

The flora of these islands cannot be described as rich but a fairer estimation of its worth is obtained by contrast with that of the surrounding country. The islands of Loch Laidon and Loch Beannach in particular provide a striking contrast to the surrounding *Molinia, Trichophorum, Eriophorum* and *Calluna* moor. At the time of visiting Eilean Iubhair in Loch Laidon the abundant bird cherry was in full flower and attracting many bees and other insects so that this little patch of woodland appeared as an oasis in the desert of Rannoch Moor. The presence of brown owls on the Loch Beannach islands and moles on Eilean Mor of Loch Sionnascaig is also remarkable.

The abundance of tall juniper on many of the islands of the west central Highlands to the west of its present mainland distribution is significant. On practically all the islands herbs and shrubs are more luxuriant than in comparable woods of the mainland and species such as *Vaccinium myrtillus, Trientalis europaea, Melampyrum pratense, Anemone nemorosa* and *Lathyrus montanus* all flower more freely.

The conclusion drawn is that the island woods are not unmodified remnants of pristine forest but are very similar in structure and floristics to the best of the surviving self-sown woods of birch, oak and pine on the mainland. They do, however, resemble primeval forest in the density of the stands, the occurrence of undershrubs and the luxuriance of the field layer.

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NOTE ON DISEASES OF BRACKEN (PTERIDIUM AQUILINUM) IN SCOTLAND.

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(Received 6th December 1957.)

An investigation of some diseases of bracken with reference to its control was carried out during 1947-48 at the Department of Botany, University of Edinburgh, and although critical determinations of the fungi concerned were not made, some of the observations have been considered worth putting on permanent record as they may stimulate other investigators to continue the work.

HISTORY OF BRACKEN DISEASE IN SCOTLAND PRIOR TO 1947.

Outbreaks of disease from "areas all over Scotland south of a line through Loch Rannoch" were noted by Alcock and Braid in 1928. A pycnidial fungus forming 'little pustules on the leaves and stems' was considered to be the probable disease-producing organism. Gregor (1935) studied the possibilities of control by disease, and distinguished two types—that described by Alcock and Braid, and the disease caused by *Corticium anceps*. Braid (1934), reviewing bracken work up to that time, further noted a "hook disease probably due to frost" and a "decline disease" where no fungus was discernible. Both these diseases occurred mostly under "open" hill grassland conditions, as did that described by Alcock and Braid (1928), whereas that described by Gregor occurred only under damp woodland conditions. Research on bracken control subsequent to Braid's review has dealt only with such methods as cutting, breaking, ploughing and chemical treatment—see Braid (1939), Griffith (1940), Millard and Stubbs (1941), Trant (1941), Copisarow (1943), and Smith (1928).

MATERIALS OF THIS INVESTIGATION.

Interest in possible biological control was renewed in 1947 when an outbreak of disease at Wakefield Baddingsgill, two miles north of West Linton, Peeblesshire, was reported by the farmer to the Plant Pathology Service, Department of Agriculture for Scotland, East Craigs, Edinburgh. Collections of material from this locality and observations made there on several subsequent occasions confirmed the presence of pycnidial fungi. Diseased bracken was also received from near Ballochraggan Cottage, Port of Menteith, collected by K. W. Braid, and from Fala Moor, Blackshiels, collected by M. Noble. The material was classifiable into two distinct disease types designated as "curl tip disease" and "Didymella disease".

"CURL TIP" DISEASE.

Most of the West Linton material and some of the material from Fala Moor came in this category.

The disease was first noticed locally during 1944-45 and again in 1946. By summer 1947, bracken which had been breast-high in 1944 was considerably thinned and reduced to 1½-2 ft. and in some patches was completely killed.

Symptoms.—The disease was essentially a dieback. Fronds at all stages of growth appeared susceptible to attack. Young fronds up to 1 ft. high were killed and turned black, while more mature fronds were only partially killed, becoming lop-sided, or arrested in growth by death of the apex. The most distinctive feature of the disease was the curling of the dead apices, which suggested the common name. These symptoms are somewhat similar to those described by Alcock and Braid (1928) and with which were associated a pycnidial fungus. Pycnidia were found on the dead parts, particularly on the curled tips where, however, they were completely hidden by the ramenta. Numerous spore tendrils were readily seen when a small piece of the dead apex was put in water. Three distinct pycnidial forms were found belonging to the genera *Stagonospora, Ascochyta* and *Phoma.* All three were always associated, *Stagonospora* being most abundant. Each was isolated in monospore culture.

The fungi concerned.—(1) *Stagonospora* sp.: pycnidia on the host ostiolate, 82-160μ, rarely up to 200μ diameter. Pycnospores hyaline, cylindrical, obtuse and slightly tapering at both ends, 1-5 septate, usually 3 septate, often slightly constricted at the cross walls; 17-28μ, average 22μ × 3μ × 6μ, average 4μ: emitted in loose tendrils. In malt-agar culture pycnidia were semi-immersed mostly round the inoculum and on several short lines radiating out from it, sparsely scattered elsewhere, 100-460μ, average 240μ. Pycnospores in culture 10-40μ, average 21μ, thus of wider range than those on the host; germination after 8 hours, 1-3 germ tubes, usually 2. Spores still viable after at least 7 months desiccation; growth rate at room temperature 0·2 cm. radius per day. As far as is known the genus had not been recorded on bracken up to 1948, and the fungus was not identified beyond the genus.

(2) *Ascochyta pteridis Bres. ex descript.*—Pycnidia on host ostiolate, approximately 110μ diameter. Pycnospores hyaline, 1-2 celled, obtuse at both ends, 10-12μ × 4-6μ, often constricted and sometimes bent at the septum, emitted in compact narrow tendrils. Pycnidia in culture much exceeded those on the host, 180-500μ, average 290μ, sometimes very irregular in shape, and sometimes several fused together, borne on the surface on strands or cords of mycelium curving clockwise away from the point of inoculation. Pycnospores ex culture exceeded those from the host, measuring 9-23μ, average 14 × 4-7μ; germination after 7 hours, 1 germ tube per cell. Pycnospores still viable after at least 7 months desiccation; growth rate at room temperature 0·15 cm. average radius per day on malt agar.

(3) *Phoma aquilina Sacc. and Penz. ex descript.*—Pycnidia on host approximately 160μ. Pycnospores 3-5 × 1·5-3μ emitted in compact narrow tendrils. Pycnidia abundant all over the mycelium in malt-agar culture, 100-250μ, average 200μ, ostiole prominent, often beaked. Pycnospores in culture 3-5μ × 1·5-3μ, germination after 6-7 hours with 1 germ tube; still viable after 7 months desiccation. Growth rate at room temperature 0·2 cm. radius per day on malt agar.

"DIDYMELLA" DISEASE.

All the material from Port of Menteith came in this category. A few fronds with the disease were also found at West Linton and in the Fala Moor collection. Prior to 1946 the disease was not prominent, but in 1946-47 attack was severe, areas up to 1 acre in extent being affected.

Symptoms.—These were quite different from those of the West Linton outbreak. Fronds were apparently attacked when more or less fully open. The commonest symptom was withering of the apex of the frond and/or one or more of the lateral pinnae which sometimes turned brown and died back for a varying distance, up to 4 ins.; this symptom somewhat resembled that described by Braid (1939) for the "Garelochhead" type of disease.

Perithecia were found most commonly embedded in rachis tissue. Only the ostiole was visible under a hand lens, but the presence of perithecia was indicated by swellings and undulations of the epidermis. The fungus was isolated in monospore culture from all three localities and identified as *Didymella hyphenis* (Cooke) Sacc. ex descript.

The fungus. Perithecia gregarious, immersed, ostiolate, 90-180μ, average 170μ, each containing about 20 mature or near-mature asci with paraphyses. Asci 60-80μ × 18-24μ. Ascospores 8, 20-24μ × 8μ, typically in 2 rows, germination after 10 hours. Growth in malt-agar culture slow, 0·15 cm. radius per day at room temperature, with small sclerotial bodies sparsely scattered on the mycelial surface when this attained 1 cm. diameter. No spore forms were found in culture.

INFECTION EXPERIMENT.

Young opening fronds grown in a greenhouse were inoculated with suspensions of spores of *Stagonospora*, *Ascochyta* and *Phoma* from isolates grown on malt agar plates. Only *Phoma* showed pathogenic properties. Young fronds 2-3 ins. high were killed 5 weeks after inoculation. *Phoma* was reisolated in culture and identified with the original inoculant.

SUMMARY.

A "Curl Tip" disease of bracken is described. The associated fungi *Stagonospora* sp., *Ascochyta pteridis* Bres. and *Phoma aquilina* Sacc. and Penz. were isolated; of the three isolates only that of *Phoma aquilina* proved pathogenic under greenhouse conditions. A second type of disease is also described and *Didymella hyphenis* (Cooke) Sacc. found to be associated; its pathogenic potential was not tested. Both diseases occur in open, less humid conditions. There is no evidence as to whether either could be utilised as a means of controlling the establishment or spread of bracken on Scottish hill-land farms.

ACKNOWLEDGMENTS.

Thanks are due to Dr. M. Noble of the Plant Pathology Station, Edinburgh, for bringing to notice the diseases at West Linton and Fala Moor, to Professor K. W. Braid, previously of the West of Scotland College of Agriculture, for material from Ballochraggan,

and to Dr. M. Wilson, Botany Department, University of Edinburgh, for his supervision and advice. Thanks are also due to Dr. C. E. Foister and Dr. M. Noble who kindly read and criticised the manuscript.

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LOCAL PLANTS OF SOUTH-WEST ABERDEENSHIRE
(V.-C. 92)

By J. GRANT ROGER
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(Received 12th December 1957).

The four species of vascular plants considered below are very local and rare in North-east Scotland and as probably very little is known of their occurrence in a few rather isolated stations, on the Braemar hills, the following notes concerning these montane habitats may be of interest.

EQUISETUM HYEMALE L.

The Rough Horsetail, as this plant has been called, is very local in Aberdeenshire generally and in the Dee valley has been noted chiefly at elevations below 500 ft. (Macgillivray, 1855, and Dickie, 1860). In recent years, however, it has been discovered in several places in the Parish of Braemar and Crathie at altitudes well above 1,000 ft. and usually associated with basic rocks. It occurs in rather wet habitats on calcareous schists and on diorite, to a height of at least 2,000 ft. on both these rock formations, and although evidently thriving best in some shade it also occurs in quite open places provided it has an adequate supply of water, and the requisite geological conditions. Probably it is quite absent from the areas of strongly acid rock in this region.

Sometimes *Equisetum hyemale,* in its Braemar stations, is found without being closely associated with other plants, but in one of its shade habitats (on the calcareous schists at c. 1,500 ft.) it grows with *Melica nutans* L., while species characteristic of the more open habitats are *Carex flacca* Schreb, *Eleocharis pauciflora* (Lightf.) Link, *Juncus alpinus* Vill., and *Saxifraga aizoides* L.

GERANIUM LUCIDUM L.

The Shining Cranesbill appears to be unknown on the hills of Deeside except within an area of several square yards at Invercauld where it grows on a steep rocky wooded hillside at an altitude of c. 1,500 ft. Here it evidently thrives best on pockets of humus-rich soil at the base of a cliff consisting chiefly of diorite, the largest and most vigorous plants being under the shade f a birch (*Betula pubescens* Ehrh.). Near the Geranium there re (apart from the birch), *Asplenium trichomanes* L., *Digitalis urpurea* L., *Juniperus communis* L., *Sorbus aucuparia* L., *Poly-odium vulgare* L., and *Viola riviniana* Rchb. On neighbouring ocks several yards away there are a few plants of *Polystichum onchitis* (L.) Roth. and *Saxifraga hypnoides* L.

In this habitat *Geranium lucidum* usually flowers from early une to late August, and bears many fruits. It has maintained ts status (1957) without spreading appreciably since the writer irst observed it on 6th June 1938. Dickie (1860) does not menion this species at all and Macgillivray (1855) records it only for he Den of Rubislaw, at Aberdeen. Trail (1923) also refers to its ccurrence at Rubislaw but considers that it is simply as a sublenizen on old walls in the Den.

ELAMPYRUM SYLVATICUM L.

This rare species, the Wood Cow-wheat, has been known to ccur by the wooded Linn of Corriemulzie, Braemar, and elsehere on Deeside for over a hundred years (Macgillivray, 1855) ut its presence, at an altitude of 2,000 ft. in a narrow non-wooded len in Mar Forest was probably not known before 12th July 954, when a few specimens were observed in full flower on northacing crags over-looking a small stream.

The rocks of the narrow glen just referred to are dioritic, with bradorite prominent in places, and the plants which accompany he Cow-wheat include *Angelica sylvestris* L., *Botrychium lunaria* L.) Sw., *Carex vaginata* Tausch, *Chamaenerion angustifolium* L.) Scop., *Coeloglossum viride* (L.) Hartm., *Crepis paludosa* (L.) oench, *Geranium sylvaticum* L., *Luzula sylvatica* (Huds.) Gaud., *axifraga oppositifolia* L., *Saussurea alpina* L., *Thelypteris ryopteris* (L.) Slosson, *Trollius europaeus* L. and *Vicia sylvatica* .

In this situation *Melampyrum sylvaticum* is far from the earest woodlands and has here one of its highest stations in the ritish Isles.

ALAMAGROSTIS EPIGEJOS (L.) Roth.

This grass, which is very local in Scotland generally, has been ecorded for a few places in South Aberdeenshire referred to by urray (1836) and Dickie (1860), but was probably not found in ar Forest until 14th September 1955. Here it grows at an elevation of c. 1,500 ft. on richly calcareous schists which are exposed on each side of a swift south-flowing stream and present a suitable habitat for a number of calciphilous species. *Melica nutans* L. and *Tortella tortuosa* (Hedw.) Limpr. may be found in close association with the *Calamagrostis* and nearby are *Asplenium viride* Huds., *Cystopteris fragilis* (L.) Bernh., *Equisetum hyemale* L., *Fragaria vesca* L., *Juniperus communis* L., *Rubus saxatilis* L., and *Saxifraga oppositifolia* L. Also on these lime-rich rocks there are plants usually more tolerant of acid conditions, e.g., *Arctostaphylos uva-ursi* (L.) Spreng., *Campanula rotundifolia* L., *Chamaenerion angustifolium* (L.) Scop., *Hypericum pulchrum* L., *Rosa villosa* L., *Solidago virgaurea* L., and *Viola riviniana* Rchb. The whole area of exposed schists is surrounded by naturally established woods of native Scots Pine.

Calamagrostis epigejos has in this remote glen of West Aberdeenshire one of its most montane stations in Britain, but here it flowers freely from July to September, and its flowering stems commonly reach two to three feet in height.

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NOTES ON THE SCOTTISH FLORA.

A LIMESTONE FLORA IN THE BEN ALDER GROUP

A band of real limestone high in the group of hills which has Ben Alder (3,754 ft.) as the highest point was found to have a rich calcicole flora when visited on 5th August 1957. This rock varies, probably owing to differences in degree of metamorphism, from a fairly hard, coarsely crystalline material to a soft, crumbly and granular type which closely resembles the famous Teesdale sugar limestone. Both types break down, the second very rapidly, to give deep, fine-textured calcareous soils. Though the actual exposures of this rock are very limited in extent, drainage water from the belt affects a large area of the slopes immediately below, giving rich basic soils and flushes. The vegetation of this tract at once recalls some of the richer ground in Breadalbane.

The most notable vascular plant encountered was *Carex atrofusca* Schkuhr, growing in fair quantity in wet stony flushes at about 2,800-2,900 ft. The following list indicates the type of vegetation characteristic of the habitat.

Agrostis canina	f
A. tenuis	f
Armeria maritima	f
Carex atrofusca	f
C. bigelowii	f
C. capillaris	la
C. demissa	a
C. panicea	f
C. saxatilis	a-ld
*Cerastium cerastoides	r
Cochlearia micacea	o
*Deschampsia alpina	o
D. caespitosa	f
Epilobium anagallidifolium	o
Equisetum hyemale	o
Festuca rubra	a
F. vivipara	f
Juncus castaneus	o
J. triglumis	f
Pinguicula vulgaris	o
Plantago maritima	o
Poa alpina	o
Polygonum viviparum	f
Saxifraga aizoides	a
S. oppositifolia	f-a
Thalictrum alpinum	f
Tofieldia pusilla	o
Trichophorum caespitosum	f
Veronica humifusa	o

Aneura pinguis	f
Scapania dentata	o

Acrocladium sarmentosum	f
A. trifarium	f
Blindia acuta	a
Bryum pseudotriquetrum	f
Campylium stellatum	a
Cratoneuron commutatum	la
Drepanocladus revolvens	a
Scorpidium scorpioides	a

*Growing towards the edge of the rich flushes, but still on more basic soils than usual.

Phleum commutatum occurs sparingly in the same kind of habitat on another slope nearby.

These flushes typically have a very open vegetation with much bare mud, gravel and stone, and water trickling over the surface, but show all transitions to closed communities. Above the flushes, drier ground only periodically irrigated by drainage from the limestone, and steep slopes with soils derived more directly therefrom, have a rich sward consisting largely of a *Silene acaulis* carpet, with a lesser quantity of *Cherleria sedoides,* and containing in profusion *Carex capillaris, Polygonum viviparum, Thalictrum alpinum* and *Saxifraga oppositifolia.* This is a familiar type of vegetation to those who know the upper slopes of Ben Lawers, as above Lochan nan Cat.

The *Silene* sward extends to the foot of the two small limestone outcrops, one at about 3,000 ft. and the other reaching 3,300 ft. The rocks tail off below and on their flanks into steep crumbling banks of rich brown soil covered mainly with *Saxifraga oppositifolia, S. hypnoides, S. aizoides* and species of *Hylocomium.* The rocks and dry ledges have *Dryas octopetala, Carex atrata, Saxifraga nivalis, Veronica alpina, Poa alpina, Oxyria digyna* and *Galium boreale.* *Saxifraga nivalis* occurs mainly on the steep rocks but a few plants depart from this normal habitat by growing on earthy banks and ledges with the carpet of other Saxifrages and moss. A soil sample from these unstable banks gave the following analysis.

Loss on Ignition	Total exch. capacity	Exch. cations (m.e.%)				free $CaCO_3$	P_2O_5	pH
		Ca	Na	K	Fe			
8·6%	6·55	6·16	0·14	0·06	0·15	0·03%	·00096%	7·32

Exchangeable calcium is relatively low, owing to the low exchange capacity of this immature soil, which is, however, base-saturated and contains free calcium carbonate.

More remarkable than the vascular plants is the bryophyte flora of these outcrops, numbering several species known mainly or only from the Lawers range. On exposed dry faces there is an abundance of *Campylium halleri, Ptychodium plicatum* and *Cratoneuron commutatum* var. *sulcatum,* the first being confined to bare rock surfaces.

Blindia caespiticia is plentiful in sheltered dry crevices and there is a good patch of *Hypnum bambergeri* in a shallow cleft. *Timmia norvegica* is scattered over earthy ledges and banks, either in small tufts or mixed with other mosses in the short sward and *Mnium spinosum* grows sparingly in the same kind of habitat.

Among the other calcicoles are more widespread species such as *Orthothecium rufescens, Encalypta alpina, Myurella julacea, Barbula ferruginascens, Hylocomium pyrenaicum, Scopania aequiloba* and *Lophozia hatcheri*. *Oncophorus virens* grows in damp places on the slopes below. The occurrence on this limestone of several mosses which are almost or completely exclusive to the Lawers range would seem to indicate that the richness, in bryophytes at least, of the Ben Lawers Schists is mainly a reflection of their high calcium content rather than of some other ion(s).

Some crags of basic mica-schist not far from the limestone produced *Cystopteris montana* in small quantity, and an abundance of *Cerastium edmondstonii*, together with the more usual montane crag-ledge plants. In acidic block screes below are *Athyrium flexile* and the western hepatics *Scapania nimbosa, S. ornithopodioides* and *Anastrophyllum donianum*. *Herberta adunca* grows on wet ledges of the more basic rocks.

Miss M. C. Gray carried out the soil analysis and to her I express my thanks. I am grateful also to Dr. D. N. McVean for his opinions on specimens of the limestone and to Mr. E. C. Wallace for checking the rarer bryophytes.

D. A. RATCLIFFE.

CARUM VERTICILLATUM (L.) KOCH IN EAST SCOTLAND.

Carum verticillatum is a species with a known western distribution in Britain. In England there is one exception to this in that it occurs in the county of Surrey. Early this summer the plant was located in the east of Scotland, on what is locally known as the "Shooting Greens" which lie near the Bridge of Potarch, some 20 miles west of Aberdeen. It grows in the vicinity of the boundary between Aberdeenshire and Kincardineshire and its distribution in this area is such that it must be recorded for both vice-counties 91 and 92. The plant is to be found in its normal habitat, a moist grassy situation associated with plants such as *Juncus acutiflorus, Nardus stricta* and *Calluna vulgaris*. Its distribution is local though, in at least one place, it is quite abundant.

A. H. SOMMERVILLE.

EQUISETUM HYEMALE L. IN W. SUTHERLAND (V.-C. 108).

This horsetail, which is very local to the north of the Great Glen, occurs in small quantity in one flush at 1,300 feet on the north-east slopes of Ben Hope. *Equisetum hyemale* grows here on wet, stony ground where the cover does not exceed 50%, and the commonest associated species include *Saxifraga aizoides, Carex flacca,* and *Eleocharis pauciflora* with *Juncus triglumis, Carex hostiana* and *Equisetum sylvaticum* occurring more rarely. This flush lies directly beneath crags of calcareous hornblende schists, and the water will have a fairly high calcium content, the flush having a pH range of 6·7-7·0.

Though not usually stated as such, *Equisetum hyemale* is almost certainly a calicole in Scotland; and thus it is interesting to note that in this new station it is again confined to the limits of the calcareous water, and does not grow on the adjacent acid, bare ground.

ROBERT E. C. FERREIRA.

SAXIFRAGA NIVALIS L. IN W. SUTHERLAND (V.-C. 108).

A rich rock-ledge vegetation on the fine N.E. cliffs of Meall Horn in the Reay Forest includes at least one small colony of *Saxifraga nivalis.* *Draba rupestris* grows more plentifully on these crags at the same altitude of 1,700 ft. and among the more usual montane plants may be mentioned *Polystichum lonchitis, Asplenium viride, Silene acaulis, Saxifraga oppositifolia* and *S. hypnoides,* all in abundance. *Draba incana* and *Poa glauca* occur very sparingly. The more notable mosses include *Hypnum hamulosum, Leptodontium recurvifolium* and *Orthothecium rufescens,* the last-named growing in particularly handsome red cushions.

The main upper cliffs of basic Moine Schist lie above a thick basal band of soft calcareous mudstones. The floras of the two parent materials show no marked differences, but the mudstones support a greater wealth of herbaceous and bryophytic ledge communities than the schists.

D. A. RATCLIFFE.

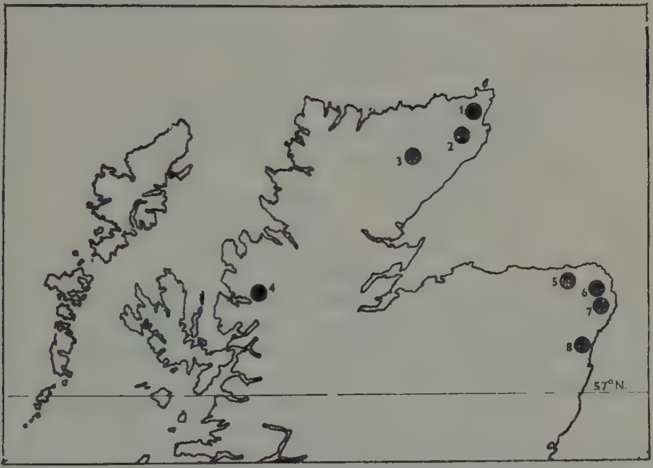
OCCURRENCE OF POLLEN OF FRAXINUS IN NORTHERN SCOTTISH PEATS.

The status of *Fraxinus excelsior* (ash) in the north of Scotland has always been regarded as doubtful and in this connection the following quotations from two recent publications are made. In Clapham, Tutin and Warburg (1952) it is said that *F. excelsior* is " . . . . perhaps introduced in some northern counties". Godwin (1956) says that the ash "may be regarded as doubtfully native in north-west Scotland."

Pollen of *Fraxinus* has been identified from eight peat deposits all north of latitude 57° N. These sites may be divided geographically into two groups of four each.

Group 1, in the counties of Caithness, Sutherland and Ross, i.e., the far north-west.

Group 2, in the coastal belt of Aberdeenshire, i.e., the extreme north-east. The map shows the locations of these sites.



Map showing the location of peat deposits from which pollen of *Fraxinus* has been identified.

The pollen diagrams from these eight peat mosses have been divided into the zones commonly applied to British profiles and the numbers of identifications of ash pollen in each zone are shown in the Tables. It is seen that the occurrence is almost entirely post-Boreal, reaching a maximum in the sub-Boreal (zone VIIb).

In pollen analytical investigations it is seldom advisable to draw conclusions from small numbers of identifications and so in this case it may be stretching the evidence too far to claim that it proves the native status of *Fraxinus*; however, when it is borne in mind that this species is one of those under-represented in pollen analyses (Faegri and Iversen 1950), amounts of only 1 or 2 per cent of total tree pollen may well be significant.

Group 1 (North-West)

	Site	County	VIII	VIIb	VIIa	VI
			Zones			
1.	Quintfall	Caithness	0	3	1	0
2.	Flows of Leanas	,,	5	3	1	0
3.	Badenloch	Sutherland	0	2	1	0
4.	Beinn Eighe	Ross	1	2	2	0
		Totals	6	10	5	0

Group 2 (North-East)

	Site	County	VIII	VIIb	VIIa	VI
			Zones			
5.	Strichen	Aberdeenshire	5	6	5	1
6.	St. Fergus	,,	2	0	1	3
7.	Rora	,,	8	6	2	0
8.	Murcar*	,,	0	3	4	1
		Totals	15	15	12	5

*Buried peat zone VIII missing.

Blytt and Sernander Climatic Periods	Equivalent Zones
Sub-Atlantic	VIII
Sub-Boreal	VIIb
Atlantic	VIIa
Boreal	VI

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S. E. Durno.

IDENTIFICATION OF FOSSIL FRUITS OF NAJAS FLEXILIS IN SCOTLAND.

Najas flexilis (Willd.) Rostk and Schmidt is a species which in the British Isles (except for a small area in Perthshire) is now confined to the west coast and Hebridean Islands. Finds of the fruits of this plant preserved in lacustrine deposits show that formerly, in late Glacial and early post Glacial times it was more widely distributed (Godwin, 1956). The map (from Godwin, 1956) shows eleven sites from which fossil fruits have been recorded—eight in Ireland, two in south-east England and one in Wales. In Britain there is no such site on record further north than East Anglia. Recently, however, the author identified fruits of *N. flexilis* in lake mud from Kilbirnie Loch, north Ayrshire. This identification was kindly confirmed by Dr. D. Walker of the Sub-Department of Quaternary Research, University of Cambridge.

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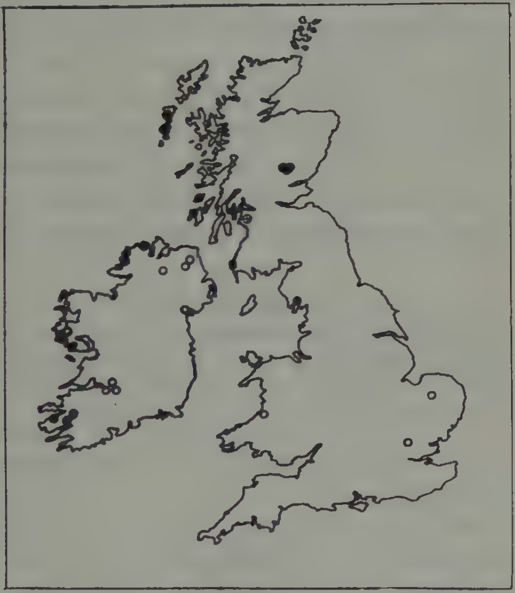
S. E. Durno.



Najas flexilis—Solid circles, present range; open circles, late-glacial and post-glacial; circle with cross, Kilbirnie Loch.

REPORT OF THE CRYPTOGAMIC SECTION, 1957.

By D. M. HENDERSON.

The 1957 Annual Autumn Cryptogamic Foray was held in Callander and district on 28th and 29th September. A small company visited the old pine woods on Blairdrummond Moss on the first day, but found the fungi disappointing in variety and on the return to Callander discovered good ground at Ballochallan. On the 29th a morning excursion to the south shores of Loch Verracher, near Invertrossachs, produced a few additions to the list including an interesting collection of *Polyporus lowei* with associated *Ptychogaster* stage. Two or three members visited Leny estate in the afternoon but made few finds.

At an informal meeting in the workroom in the British Legion hall it was decided to hold next year's foray in Edzell, if possible, early in September. The Secretary, who was unable to be present, is grateful to Mr. P. D. Orton for the list of fungi and notes on the excursions. The section was indebted to the proprietors of Blairdrummond and Leny estates for permission to visit their grounds.

LIST OF FUNGI COLLECTED.

(Agarics according to Pearson & Dennis: Checklist.)

(a) Blairdrummond.
(b) Ballochallan.
(c) Invertrossachs.
(d) Leny.

AMANITA FULVA, a, b; RUBESCENS, a, b, c; MUSCARIA, a, b.

LEPIOTA AMIANTHINA, a, c.

ARMILLARIA MELLEA, b, c; MUCIDA, b.

TRICHOLOMA VIRGATUM, b; SAPONACEUM, b; RUTILANS, a, d; COLUMBETTA, b.

MYCENA GALOPUS, b, c; GALERICULATA, b, c; SMITHIANA Kuhner, b; URACEA, a; ALCALINA, c; SANGUINOLENTA, b, c; AMICTA, b; STYLOBATES, b.

CLITOCYBE GILVA, a; LANGEI, b; CLAVIPES, a; UMBONATA, b.

LACCARIA LACCATA, a, b, c; AMETHYSTINA, c.

COLLYBIA DISTORTA, b, c; TUBEROSA, c; BUTYRACEA, a; ATRATA, d.

MARASMIUS CONFLUENS, a.

OMPHALIA UMBELLIFERA, a, c.

PLEUROTUS PORRIGENS, b.

LENTINUS COCHLEATUS, c.

HYGROPHORUS PUSTULATUS, a.

LACTARIUS TURPIS, b. c; VIETUS, b. c; VELLEREUS, c; QUIETUS, b. c; GLYCYOSMUS, b; OBSCURATUS, c; CAMPHORATUS, c; RUFUS, a; TABIDUS, b, c.

RUSSULA EMETICA, a; OCHROLEUCA, a, b, c; FELLEA, b; FALLAX, b; CLAROFLAVA, b; CYANOXANTHA, c; NIGRICANS, b, c; VENOSA, b.

CANTHARELLUS CIBARIUS, c.

PLUTEUS CERVINUS, c.

ENTOLOMA NIDOROSUM, b.

FLAMMULA PENETRANS, a, c; ALNICOLA, d; SCAMBA, b, c.

GALERA RUBIGINOSA, a; TIBIICYSTIS, b.

CREPIDOTUS BRESADOLAE Pilat, b.

CORTINARIUS CROCOLITUS, b; FLEXIPES, b; RIGIDUS, b; ANOMALUS, c.

TUBARIA CONSPERSA, b.

INOCYBE GEOPHYLLA, a.

PAXILLUS INVOLUTUS, a, b, c.

STROPHARIA SEMIGLOBATA, a.

HYPHOLOMA CAPNOIDES, a; SUBLATERITIUM, c; FASCICULARE, c; UDA, a.

PSATHYRELLA OBTUSATA, b; HYDROPHILA, c.

BOLETUS BADIUS, b; PIPERATUS, c; CHRYSENTERON, c.

POLYPORUS LACTEUS, a, c; LOWEI, c; ADIPOSUS, b; BETULINUS, b.

PORIA VERSIPORA, a, b.

FOMES FOMENTARIUS, b; NIGRICANS, a.

TRAMETES MOLLIS, b.

LENZITES SAEPIARIA, d.

COMMITTEE FOR THE STUDY OF THE SCOTTISH FLORA.

Third Annual Report to 31st December 1957.

The Committee has met three times (Glasgow in April, Aberdeen in July and Perth in October) and has arranged spring and autumn Exhibition Meetings, over both of which the Chairman, Mr. B. L. Burtt, presided. Field Meetings have been held at Callander (17th-20th May) led by Miss E. Beattie and attended by 5 others; at Hunter's Quay (24th-27th May) led by Mr. R. Mackechnie and attended by 8 others; at Fort William (28th June-5th July) led by Miss M. McC. Webster and attended by 10 others; at Moffat (3rd-10th August) led by Mr. F. H. Perring and attended by 14 others. A one-day Junior Meeting, led by Mr. P. S. Green and attended by 29, was held at Linlithgow on Saturday, 1st June. Reports of these meetings will appear in *Proc. bot. Soc. British Isles.*

The Spring Exhibition Meeting took place in Oban High School, by kind permission of the Rector, on Saturday, 9th March 1957, and attracted an attendance of some 70 people. Mr. A. H. Davidson, Principal Teacher of Science in the High School, kindly made the local arrangements. Some of the exhibits shown in Glasgow in the autumn (*Proc. bot. Soc. British Isles,* **2**, 314) were displayed, and Mr. Ribbons showed colour transparencies of *Phyllodoce coerulea* taken on the Sow of Atholl, and of Scottish coastal plants. The pictures were commented on by Mr. Ribbons and Mr. Mackechnie Mr. Burtt spoke about the Distribution Maps Scheme and the forthcoming field meeting to be held in Oban. Tea was provided through the kindness of Mr. Davidson and his helpers.

The Autumn Meeting was held at the Royal Botanic Garden, Edinburgh, on Saturday, 9th November 1957, and about 80 visitors were present. The following exhibits were shown: original drawings of British plants by Miss S. Ross-Craig; specimens of *Calamagrostis epigejos,* a very local grass in Scotland occurring chiefly in damp woods and gathered from a well-established colony in what is probably the highest station for the species in Britain (J. Grant Roger); *Luzula* species in Britain

(Miss J. Buchanan); *Alchemilla* species (Miss U. Duncan); *Hieracium* and *Euphrasia* from the Moffat Field Meeting (F. H. Perring); *Chara* species (Mr. Horsman); Arctic-Alpine plants to be sought for in Britain—see *Watsonia,* **3**, 34—(P. S. Green); specimens of some of the new records for the Island of Foula which, together with other unpublished records, some of which were made by Mr. K. J. Messenger in 1956, will eventually add some 30 species to the list published by J. G. Urquhart in 1929; specimens from Fair Isle of records additional to the list published by Pritchard in 1957 (A. Currie); a sheet of *Puccinellia rupestris,* a southern species presumably introduced into the station in Kincardineshire (is it still there?); specimens collected on the expedition to the Island of Jura by the Edinburgh University Biological Society (R. B. Knox); specimen of *Calamagrostis canescens* from Penicuik, an old record of this plant which has not been confirmed recently and which should be sought in damp open woodland in the area; *Puccinellia* spp. from the Isle of May (W. J. Eggeling) and from Fair Isle (A. Currie), material which is at present under investigation at Kew; *Carum verticillatum,* which is generally restricted in Scotland to the western parts, from a new station in Kincardineshire (Mrs. A. Somerville).

Before tea a meeting was held at which the Chairman drew attention to the requirements of the Distribution Maps Scheme in Scotland next year, and coloured slides of interesting Scottish plants were shown.

Plants from the herbarium of the Botany Department of the University of Aberdeen were exhibited on the first evening of the Field Meeting at Aberdeen. These included: plants of the area to be covered by the Field Meeting (*Lycopodium inundatum,* etc.); rare plants of north-east Scotland (*Cystopteris dickieana,* etc.); past and present records (*Trichophorum alpinum* from Forfar, *Phyllodoce coerulea* from Aviemore, *Carex buxbaumii* from Lough Neagh, Arisaig, and East Inverness-shire, *Teucrium scordium* from Methven, *Erica ciliaris* from Galway, *Carum verticillatum* from Kincardineshire and South Aberdeenshire and *Asplenium septentrionale* from Braemar).

The services of Miss M. S. Campbell, who left the Committee on becoming resident abroad, have been very much appreciated, and she has been invited to attend any Committee meetings held when she is in Britain.

The Accounts showed a deficit of 10s. 6d. over the years 1955-56; this amount has been refunded in equal sums by the two sponsoring societies, the Botanical Society of the British Isles and the Botanical Society of Edinburgh. The two Societies have been asked to supply semi-permanent exhibits for use at the Exhibition Meetings, and the exhibit of the Botanical Society of Edinburgh was displayed at the November meeting.

The Secretary once again has pleasure in expressing his Committee's thanks to the Officers of the sponsoring Societies, to the leaders of the field meetings and to other members and friends who have helped to organise the activities of 1957.

B. W. Ribbons, *Honorary Secretary.*

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